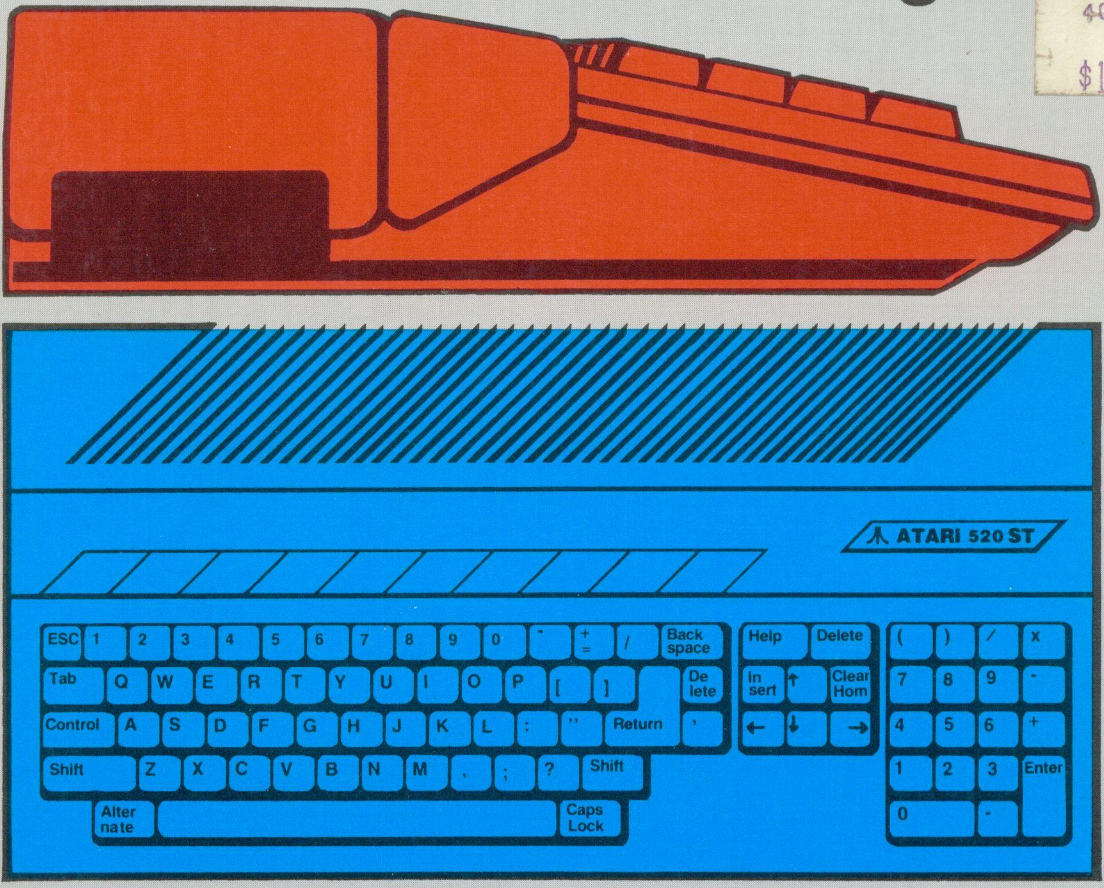
Third Revision—Includes blitter chip information

ATARI® ST™
INTERNALS

The authoritative insider's guide



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ATARI ST INTERNALS

The authoritative insider's guide

By K. Gerits, L. Englisch, R. Bruckmann

A Data Becker Book

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The Integrated Circuits

1.1 The 68000 Processor

The 68000 microprocessor is the heart of the entire Atari ST system. This 16-bit chip is in a class by itself; programmers and hardware designers alike find the chip very easy to handle. From its initial development by Motorola in 1977 to its appearance on the market in 1979, the chip was to be a competitor to the INTEL 8086/8088 (the processor used in the IBM-PC and its many clones). Before the Atari ST's arrival on the marketplace, there were no affordable 68000 machines available to the home user. Now, though, with 16-bit computers becoming more affordable to the *common* man, the 8-bit machines won't be around much longer.

What does the 68000 have that's so special? Here's a very incomplete list of features:

16 data bits
24 address bits (16-megabyte address range!!)
all signals directly accessible without multiplexer
hassle-free operation of "old" 8-bit peripherals
powerful machine language commands
easy-to-learn assembler syntax
14 different types of addressing
17 registers each having 32-bit widths

These specifications (and many yet to be mentioned here) make the 68000 an incredibly good microprocessor for home and personal computers. In fact, as the price of memory drops, you'll soon be seeing 68000-based 64K machines for the same price as present-day 8-bit computers with the same amount of memory.

1.1.1 The 68000 Registers

Let's take a look at 68000 design. Figure 1.1-1 shows the 17 onboard 32-bit registers, the program counter and the status register.

The eight data registers can store and perform calculations, as well as the normal addressing tasks. Eight-bit systems use the accumulators for this, which limits the programmer to a total of 8 accumulators. Our 68000 data registers are quite flexible; data can be handled in 1-, 8-, 16- and 32- bit sizes. Even four-bit operations are possible (within the limits of Binary Coded Decimal counting). When working with 32-bit data, all 32 bits can be handled with a single operation. With 8- and 16-bit data, only the 8th or 16th bit of the data register can be accessed.

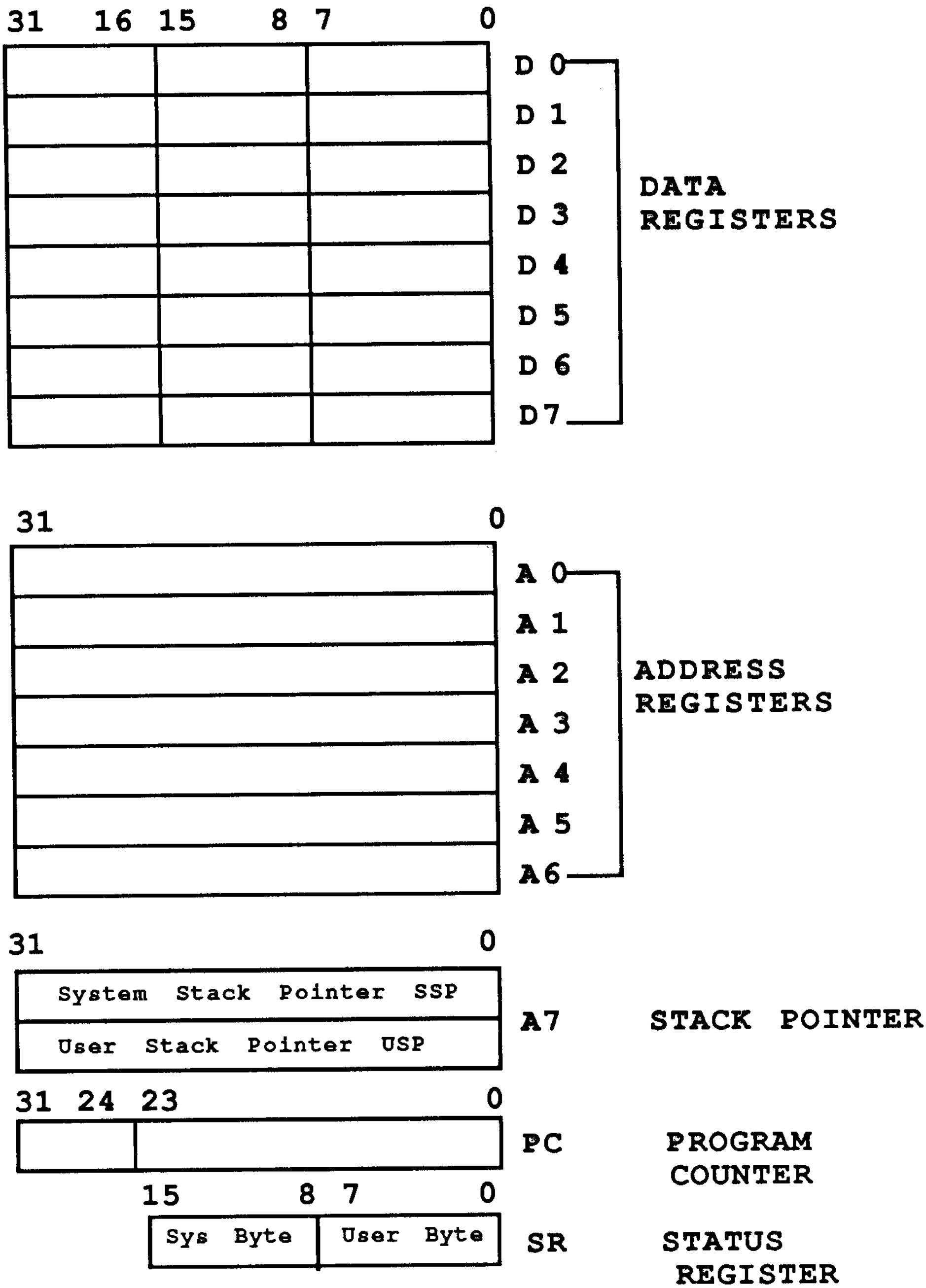
The address registers aren't as flexible for data access as are the data registers. These registers are for addressing, not calculation. Processing data is possible only with word (16-bit) and longword (32-bit) operations. The address registers must be looked at as two distinct groups, the most versatile being the registers A0-A6. Registers A7 and A7' fulfill a special need. These registers are used as the stack pointer by the processor. Two stack pointers are needed to allow the 68000 to run in USER MODE and SUPERVISOR MODE. Register A7 declares whether the system is in USER or SUPERVISOR mode. Note that the two registers work "under" A7, but the register contents are only available to the respective operating mode. We'll discuss these operating modes later.

The program counter is also considered a 32-bit register. It is theoretically possible to handle an address range of over 4 gigabytes. But the address bits A24-A31 aren't used, which "limits" us to 16 megabytes.

The 68000 status register comprises 16 bits, of which only 10 bits are used. This status register is divided into two halves: The lower eight bits (bits 0 to 4 proper) is the "user byte". These bits, which act as flags most of the time, show the results of arithmetical and comparative operations, and can be used for program branches hinging on those results. We'll look at the user byte in more detail later; for now, here is a brief list:

```
BIT 0 = Carry flag      BIT 1 = Overflow flag
BIT 2 = Zero flag       BIT 3 = Negative flag
BIT 4 = eXtend flag
```

Figure 1.1-1 68000 Registers



Bits 8-10, 13 and 15 make up the status register's system byte. The remaining bits are unused. Bit 15 works as a trace bit, which lets you do a software controlled single-step execution of any program. Bit 13 is the supervisor bit. When this bit is set, the 68000 is in supervisor mode. This is the normal operating mode; all commands are executed in this mode. In user mode, in which programs normally run, privileged instructions are inoperative. A special hardware design allows access into the other memory range while in user mode (e.g., important system variables, I/O registers). The system byte of the status register can only be manipulated in supervisor mode; but there's a simple method of switching between modes.

Bits 8 and 10 show the interrupt mask, and run in connection with pins IPL0-IPL2.

The 68000 has great potential for handling interrupts. Seven different interrupt priorities exist, the highest being the "non-maskable interrupt"; NMI. This interrupt recognizes when all three IPL pins simultaneously read low (0). If, however, all three IPL pins read high, there is no interrupt, and the system operates normally. The other six priorities can be masked by appropriate setting of the system byte of the status register. For example, if bit I2 of the interrupt mask is set, while I0 and I1 are off, only levels 7, 6 and 5 (000, 001 and 010) are recognized. All other combinations from IPL0-IPL2 are ignored by the processor.

1.1.2 Exceptions on the 68000

We've spoken of interrupts as if the 68000 behaves like other microprocessors. Interrupts, according to Motorola nomenclature, are an external form of an **exception** (the machine can interrupt what it's doing, do something else, and return to the interrupted task if needed). The 68000 distinguishes between normal operation and exception handling, rather than between user and supervisor mode. One such set of exceptions are the interrupts. Other things which cause exceptions are undefined opcodes, and word or longword access to a prohibited address.

To make exception handling quicker and easier, the 68000 reserves the first 1K of memory (1024 bytes, $000000-$0003FF). The exception table is located here. Exceptions are all coded as one of four bytes of a longword. Encountering an exception triggers the 68000, and the address of the corresponding table entry is output.

A special exception occurs on reset, which requires 8 bytes (two longwords); the first longword contains the standard initial value of the supervisor stack pointer, while the second longword contains the address of the reset routine itself. See Chapter 3.3 for the design and layout of the exception table.

1.1.3 The 68000 Connections

The connections on the 68000 are divided into eight groups (see Figure 1.1-3 on page 11).

The first group combines data and address busses. The data bus consists of pins D0-D15, and the address bus A1-A23. Address bit A0 is not available to the 68000. Memory can be communicated with words rather than bytes (1 word=2 bytes=16 bits, as opposed to 1 byte=8 bits). Also, the 68000 can access data located on odd addresses as well as even addresses. The signals will be dealt with later.

It's important to remember in connection with this, that by word access to memory, the byte of the odd address is treated as the low byte, and the even

address is the high byte. Word access shouldn't stray from even addresses. That means that opcodes (whether all words or a single word) must always be located at even addresses.

When the data and address bus are in "tri-state" condition, a third condition (in addition to high and low) exists, in which the pins offer high resistance, and thus are inactive on the bus. This is important in connection with Direct Memory Access (DMA).

The second group of connections comprise the signals for asynchronous bus control. This group has five signals, which we'll now look at individually:

1) R/W (READ/WRITE)

The R/W signal is a familiar one to all microprocessors. This indicates to memory and peripherals whether the processor is writing to or reading data from the address on the bus.

2) AS (ADDRESS STROBE)

Every processor has a signal which it sends along the data lines signaling whether the address is ready to be used. On the 68000, this is known as the ADDRESS STROBE (low active).

3) UDS (UPPER DATA STROBE)
4) LDS (LOWER DATA STROBE)

If the 68000 could only process an entire memory word (two bytes) simultaneously, this signal wouldn't be necessary. However, for individual access to the low-byte and high-byte of a word, the processor must be able to distinguish between the two bytes. This is the task performed by UDS and LDS. When a word is accessed, both strobes are activated simultaneously (active=low). Accessing the data at an odd address activates the Lower Data Strobe only, while accessing data at an even address activates the Upper Data Strobe.

Bit A0 from the address bus is used in this case. After every access when the system must distinguish between three conditions (word, even byte, odd byte), A0 determines how to complete the access.

LDS and UDS are tri-state outputs.

5) DTACK

The above signals (with the exception of UDS and LDS) are needed by an 8-bit processor. DTACK takes a different path; DTACK must be low for any write or read access to take place. If the signal is not low within a bus cycle, the address and data lines "freeze up" until DTACK turns low. This can also occur in a WAIT loop. This way, the processor can slow down memory and peripheral chips while performing other tasks. If no wait cycles are used on the ST, the processor moves "at full tilt".

The third group of connections, the signals VMA, VPA and E are for synchronous bus control. A computer is more than memory and a microprocessor; interfaces to keyboard, screen, printer, etc. must be available for communication. In most cases, interfacing is handled by special ICs, but the 68000 has a huge selection of interface chips onboard. For hardware designers we'll take a little time explaining these synchronous bus signals.

The signal E (also known as Φ2 or phi 2) represents the reference count for peripherals. Users of 6800 and 6502 machines know this signal as the system counter. Whereas most peripheral chips have a maximum frequency of only 1 or 2 mHz, the 68000 has a working speed of 8 mHz, which can increased to 10 by the E signal. The frequency of E in the ST is 800 kHz. The E output is always active; it is not capable of a TRI- STATE condition.

The signal **VPA** (Valid Peripheral Address) sends data over the synchronous bus, and delegates this transfer to specific sections of the chip. Without this signal, data transfer is performed by the asynchronous bus. VPA also plays a role in generating interrupts, as we'll soon see.

VMA (Valid Memory Address) works in conjunction with the VPA to produce the CHIP-select signal for the synchronous bus.

The fourth group of 68000 signals allows simple DMA operation in the 68000 system. DMA (Direct Memory Access) directly accesses the DMA controllers, which control computer memory, and which is the fastest method of data transfer within a computer system.

To execute the DMA, the processor must be in an inactive state. But for the processor to be signaled, it must be in a "sleep" state; the low BR signal

(Bus Request) accomplishes this. On recognizing the BR signal, the 68000's read/write cycle ends, and the BG signal (Bus Grant) is activated. Now the DMA-requested chip waits until the signals AS, DTACK and (when possible) BGACK are rendered inactive. As soon as this occurs, the BGACK (Bus Grant Acknowledge) is activated by the requested chip , and takes over the bus. All essential signals on the processor are made high; in particular, the data, address and control busses are no longer influenced by the processor. The DMA controller can then place the desired address on the bus, and read or write data. When the DMA chip is finished with its task, the BGACK signal returns to its inactive state, and the processor again takes over the bus.

The fifth group of signals on the 68000 control interrupt generation. The 68000's "user's choice" interrupt concept is one of its most extraordinary performing qualities; you have 199 (!) interrupt vectors from which to choose. These interrupt vectors are divided into 7 non-auto-vectors and 192 auto-vectors, plus 7 different priority lines.

Interrupts are triggered by signals from the three lines IPL0 to IPL2; these three lines give you eight possible combinations. The combination determines the priority of the interrupt. That is, if IPL0, IPL1 and IPL2 are all set high, then the lowest priority is set ("no interrupt"). However, if all three lines are low, then highest priority takes over, to execute a non-maskable interrupt. All the combinations in between affect special bits in the 68000's status register; these, in turn, affect program control, regardless of whether or not a chosen interrupt is allowable.

Wait -- what are auto-vectors and non-auto-vectors? What do these terms mean?

If requesting an interrupt on IPL0-IPL2 while VPA is active (low), the desired code is directly converted from the IPL pins into a vector number. All seven interrupt codes on the IPL pins have their own vectors, though. The auto-vector concept automatically gives the vector number of the IPL interrupt code needed.

When DTACK, instead of VPA, is active on an interrupt request, the interrupt is handled as a non-auto-vector. In this case, the vector number from the triggered chip is produced by DTACK on the 8 lowest bits of the data bus. Usually (though not important here), the vector number is placed into the user-vector range ($40--$FF).

The sixth set of connections are the three "function code" outputs FC0 to FC2. These lines handle the status display of the processor. With the help of these lines, the 68000 can expand to four times 16 megabytes (64 megabytes). This extension requires the MMU (Memory Management Unit). This MMU does more than handle memory expansion on the ST; it also recognizes whether access is made to memory in user or supervisor mode. This information is conveyed to a memory range only accessible in supervisor mode. Also, the interrupt verification uses this information on the FC line. The figure below shows the possible combinations of functions.

Figure 1.1-3

FC2	FC1	FC0	Status
0	0	0	unused
0	0	1	User-mode data access
0	1	0	User-mode program
0	1	1	unused
1	0	0	unused
1	0	1	Supervisor data access
1	1	0	Supervisor program
1	1	1	Interrupt verification

The seventh group contains system control signals. This group applies to the input CLK and BERR, as well as the bidirectional lines RESET and HALT.

The input CLK will generate the working frequency of the processor. The 68000 can operate at different speeds; but the operating frequency must be specified (4, 6, 8, 10, or even 12.5 mHz). The ST has 8 mHz built in, while the minimum operating frequency is 2 mHz. The ST's 8 mHz was chosen as a "middle of the road" frequency to avoid losing data at higher frequencies.

The RESET line is necessary to check for system power-up. The 68000's data page distinguishes between two different reset conditions. On power-up, RESET and HALT are switched low for at least 100 milliseconds, to set up a proper initialization. Every other initialization requires a low impulse of at least 4 "beats" on the 68K.

Here is what RESET does in detail. The system byte of the status register is loaded with the value $27. Once the processor is brought into supervisor

status, the Trace flag in the status register is cleared, and the interrupt level is set to 7 (lowest priority, all lines allowable). Additionally, the supervisor stack pointer and program counter are loaded with the contents of the first 8 bytes of memory, whereby the value of the program counter is set to the beginning of the reset routine.

However, since the RESET line is bi-directional, the processor can also have RESET under program control during the time the line is low. The RESET instruction serves this purpose, when the connection is low for 124 "beats". It's possible to re-initialize the peripheral ICs at any time, without resetting the computer itself. RESET time puts the 68000 into a NOP state -- a reset is unstoppable once it occurs.

The HALT pin is important to the RESET line's existence (as we mentioned above), in order to initialize things properly. This pin has still more functions: when the pin is low while RESET is high, the processor goes into a halt state. This state causes the DMA pin to set the processor into the tri-state condition. The HALT condition ends when HALT is high again. This signal can be used in the design of single-step control.

HALT is also bi-directional. When the processor signals this line to become low, it means that a major error has occurred (e.g., doubled bus and address errors).

A low state on the BERR pin will call up exception handling, which runs basically like an external interrupt. In an orderly system, every access to the asynchronous bus quits with the DTACK signal. When DTACK is outputting, however, the hardware can produce a BERR, which informs the processor of any errors found. A further use for BERR is in connection with the MMU, to test for proper memory access of a specific range; this access is signaled by the FC pins. If protected memory is tried for in user mode, a BERR will turn up.

When both BERR and HALT are low, the processor will "re-execute" the instruction at which it stopped. If it doesn't run properly on the second "go-round", then it's called a *doubled* bus error, and the processor halts.

The eighth group of connections are for voltage and ground.

1.2 The Custom Chips

The Atari ST has four specially developed ICs. These chips (GLUE, MMU, DMA and SHIFTER) play a major role in the low price of the ST, since each chip performs several hundred overlapping functions. The first prototype of the ST was 5 X 50 X 30 cm. in size, mostly to handle all those TTL ICs. Once multiple functions could be crammed into four ICs, the ST became a saleable item. Then again, the present ST hasn't quite reached the ultimate goal -- it still has eight TTLs.

Naturally, since these chips were specifically designed by Atari for the ST, they haven't been publishing any spec sheets. Even without any data specs, we can give you quite a bit of information on the workings of the ICs.

An interesting fact about these ICs is that they're designed to work in concert with one another. For example, the DMA chip can't operate alone. It hasn't an address counter, and is incapable of addressing memory on its own (functions which are taken care of by the MMU). It's the same with SHIFTER -- it controls video screen and color, but it can't address video RAM. Again, MMU handles the addressing.

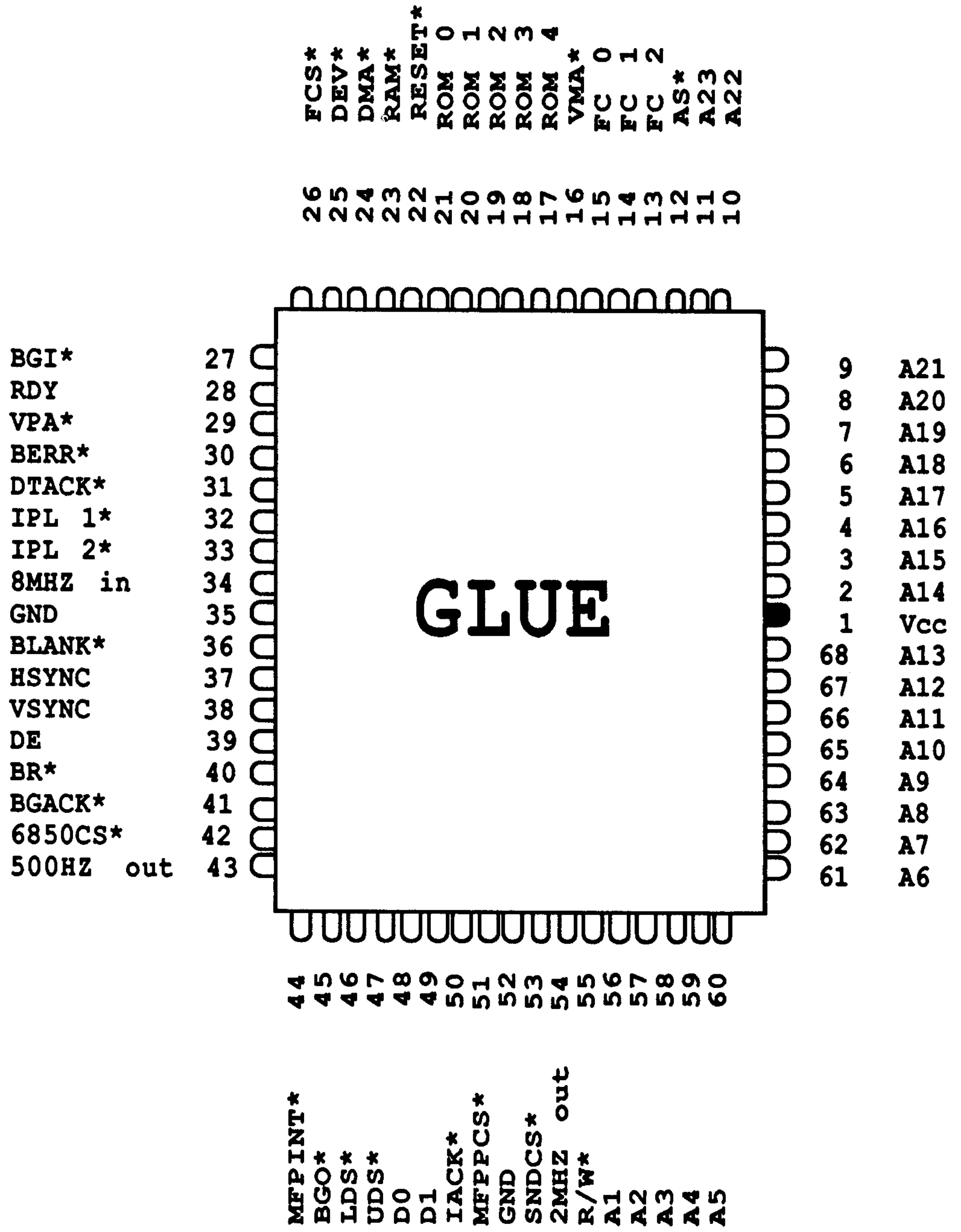
The system programmer can easily figure out which IC has which register. It is only essential to be able to recognize the address of the register, and how to control it. We're going to spend some time in this chapter exploring the pins of the individual ICs.

The most important IC of the "foursome" is GLUE. Its title speaks for the function -- a glue or paste. This IC, with its 68 pins, literally holds the entire system together, including decoding the address range and working the peripheral ICs.

Furthermore, the DMA handshake signals BR, BG and BGACK are produced/output by GLUE. The time point for DMA request is dictated by GLUE by the signal from the DMA controller. GLUE also has a BG (Bus Grant) input, as well as a BGO (Bus Grant Out).

The interrupt signal is produced by GLUE; in the ST, only IPL1 and IPL2 are used for this. Without other hardware, you can't use NMI (interrupt level 7). The pins MFPINT and IACK are used for interrupt control.

Figure 1.2-1 GLUE



The function code pins are guided by GLUE, where memory access tasks are performed (range testing and access authorization). Needless to say, the BERR signal is also handled by this chip. VPA is particularly important to the peripheral ICs and the appropriate select signals.

GLUE generates a timing frequency of 8 mHz. Frequencies between 2 mHz (sound chip's operating frequency) and 500 kHz (timing for keyboard and MIDI interface) can be produced.

HSYNC, VSYNC, BLANK and DE (Display Enable) are generated by GLUE for monitor operation. The synchronous timing can be switched on and off, and external sync-signals sent to the monitor. This will allow you to synchronize the ST's screen with a video camera.

The MMU also has a total of 68 pins. This IC performs three vital tasks. The most important task is coupling the multiplexed address bus of dynamic RAM with the processor's bus (handled by address lines A1 to A21). This gives us an address range totaling 4 megabytes. Dynamic RAM is controlled by RAS0, RAS1, CAS0L, CAS0H, CAS1L and CAS1H, as well as the multiplexed address bus on the MMU. DTACK, R/W, AS, LDS and UDS are also controlled by MMU.

We've already mentioned another important function of the MMU: it works with the SHIFTER to produce the video signal (the screen information is addressed in RAM, and SHIFTER conveys the information). Counters are incorporated in the MMU for this; a starting value is loaded, and within 500 nanoseconds, a word is addressed in memory and the information is sent over DCYC. The starting value of the video counter (and the screen memory position) can be shifted in 256-byte increments.

Another integrated counter in MMU, as mentioned earlier, is for addressing memory using the DMA. This counter begins with every DMA access (disk or hard disk), loading the address of the data being transferred. Every transfer automatically increments the counter.

The SHIFTER converts the information in video RAM into impulses readable on a monitor. Whether the ST is in 640 X 200 or 320 X 200 resolution, SHIFTER is involved.

Figure 1.2-2 MMU

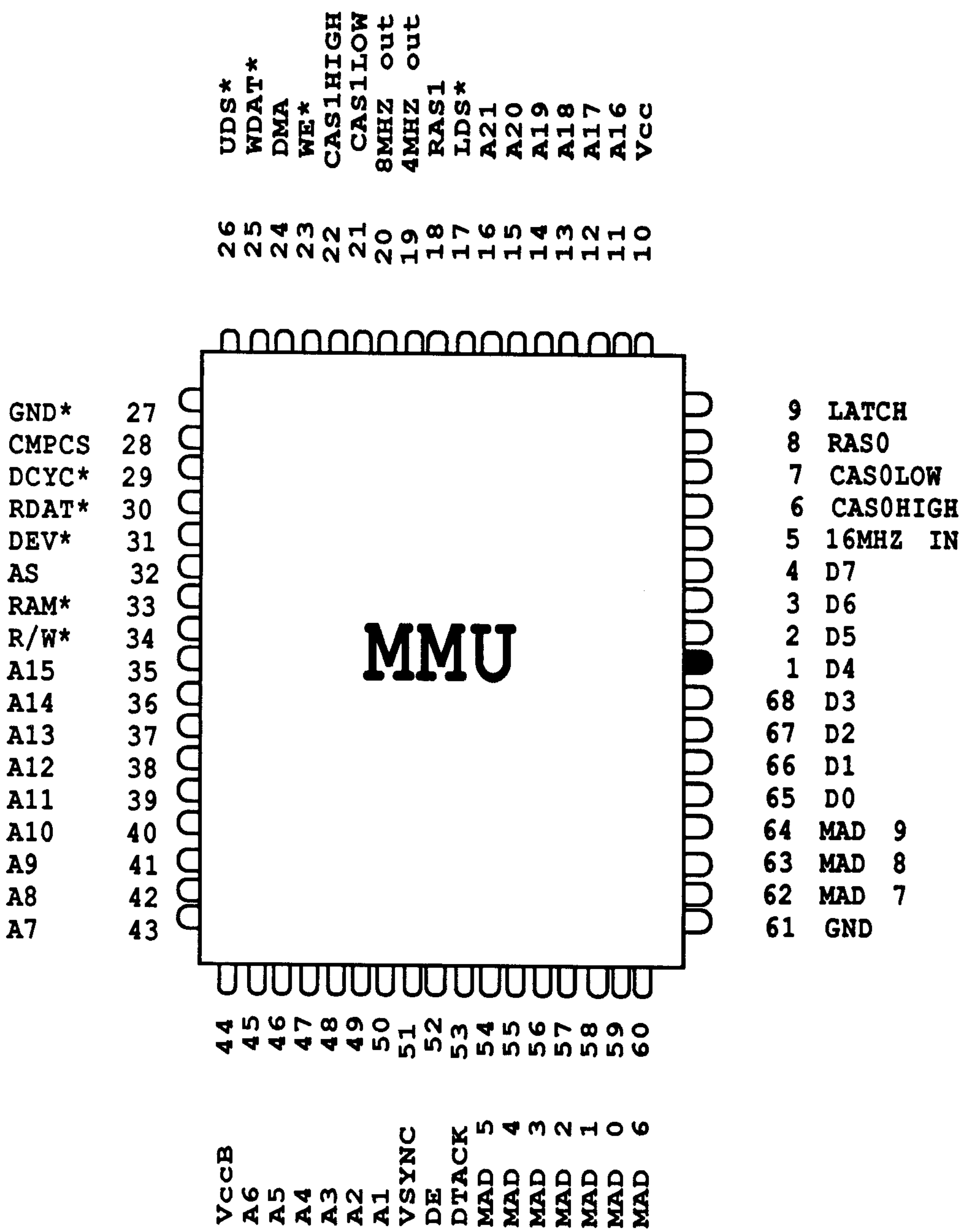
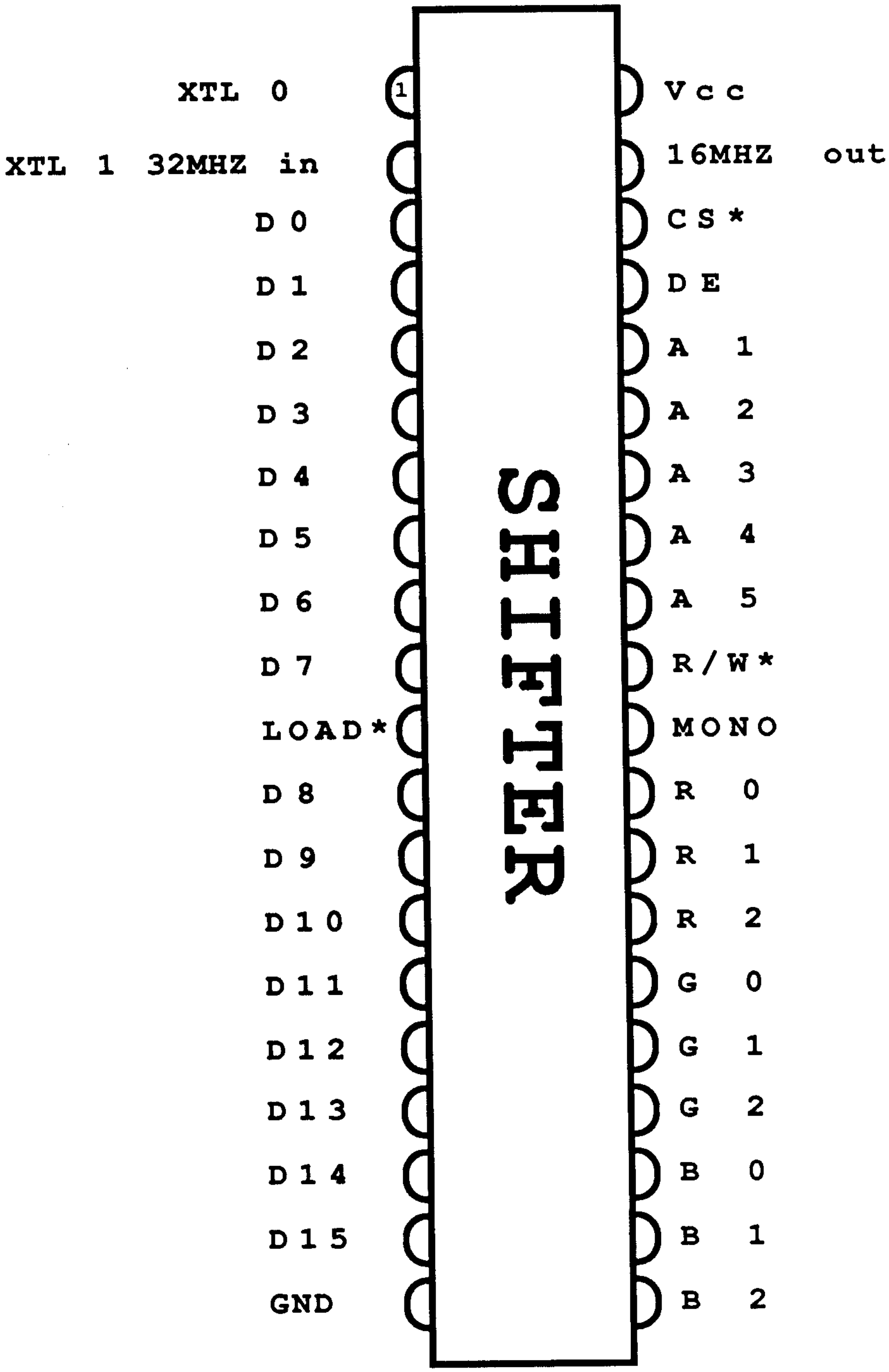


Figure 1.2-3 SHIFTER



The information from RAM is transferred to SHIFTER on the signal LOAD. A resolution of 640 X 400 points sends the video signal over the MONO connector. Since color is impossible in that mode, the RGB connection is rendered inactive. The other two resolutions set MONO output to inactive, since all screen information is being sent out the RGB connection in those cases.

The third color connection works together with external equipment as a digital/analog converter. Individual colors are sent out over different pins, to give us color on our monitor. Pins R1- R5 on the address bus make up the "palette registers". These registers contain the color values, which are placed in individual bit patterns. The 16 palette registers hold a total of 16 colors for 320 X 200 mode. Note, however, that since these are based on the "primary" colors red, green and blue, these colors can be adjusted in 8 steps of brightness, bringing the color total to 512.

The DMA controller is like SHIFTER, only in a 40-pin housing; it is used to oversee the floppy disk controller, the hard disk, and any other peripherals that are likely to appear.

The speed of data transfer using the floppy disk drive offers no problems to the processor. It's different with hard disks; data moves at such high speed that the 68000 has to send a "pause" over the 8 mHz frequency. This pace is made possible by the DMA.

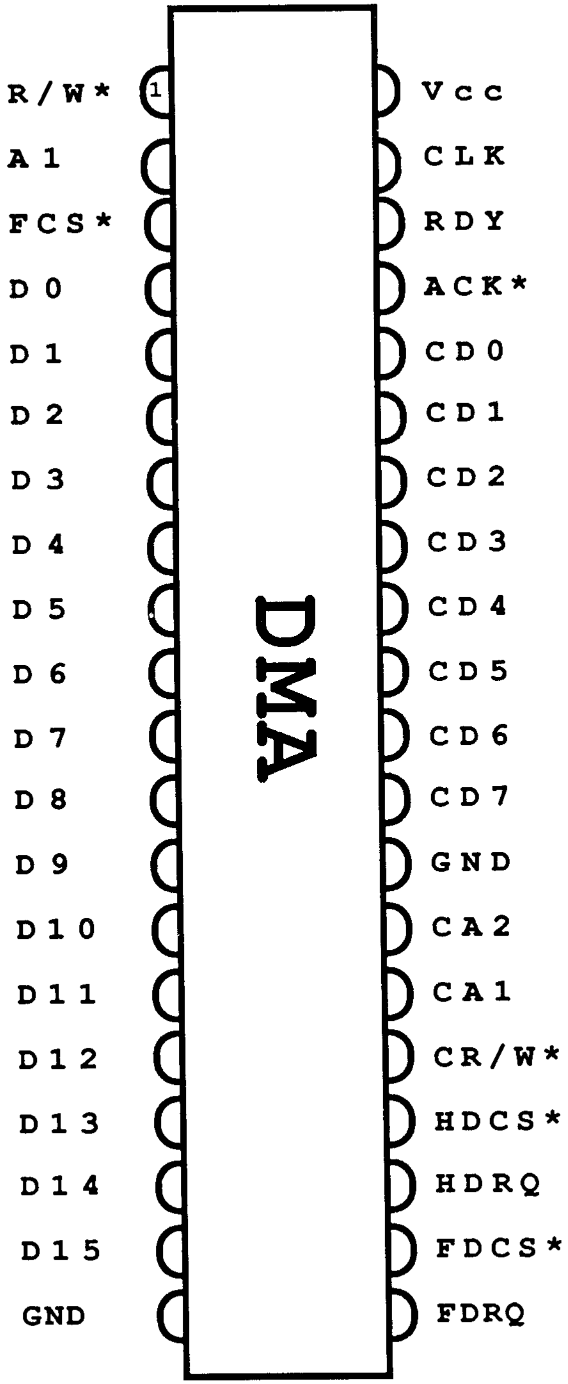
The DMA is joined to the processor's data bus to help transfer data. Two registers within the machine act as a bi-directional buffer for data through the DMA port; we'll discuss these registers later. One interesting point: The processor's 16-bit data bus is reduced to 8 bits for floppy/hard disk work. Data transfer automatically transfers two bytes per word.

The signals CA1, CA2, CR/W, FDCS and FDRQ manage the floppy disk controller. CA1 and CA2 are signals which the floppy disk controller (FDC) uses to select registers. CR/W determine the direction of data transfer from/to the FDC, and other peripherals connected to the DMA port.

The RDY signal communicated with GLUE (DMA-request) and MMU (address counter). This signal tells the DMA to transfer a word.

As you can see, these ICs work in close harmony with one another, and each would be almost useless on its own.

Figure 1.2-4 DMA



1.3 The WD 1772 Floppy Disk Controller

Although the 1772 from Western Digital has only 28 pins, this chip contains a complete floppy disk controller (FDC) with capabilities matching 40-pin controllers. This IC is software-compatible with the 1790/2790 series. Here are some of the 1772's features:

Simple 5-volt current
Built-in data separator
Built-in copy compensation logic
Single and double density
Built-in motor controls

Although the user has his/her choice of disk format, e.g. sector length, number of sectors per track and number of tracks per diskette, the "normal" format is the optimum one for data transfer. So, Apple or Commodore diskettes can't be used.

Before going on to details of the FDC, let's take a moment to look at the 28 pins of this IC.

1.3.1 1772 Pins

These pins can be placed in three categories. The first group consists of the power connections.

Vcc:

+5 volts current.

GND:

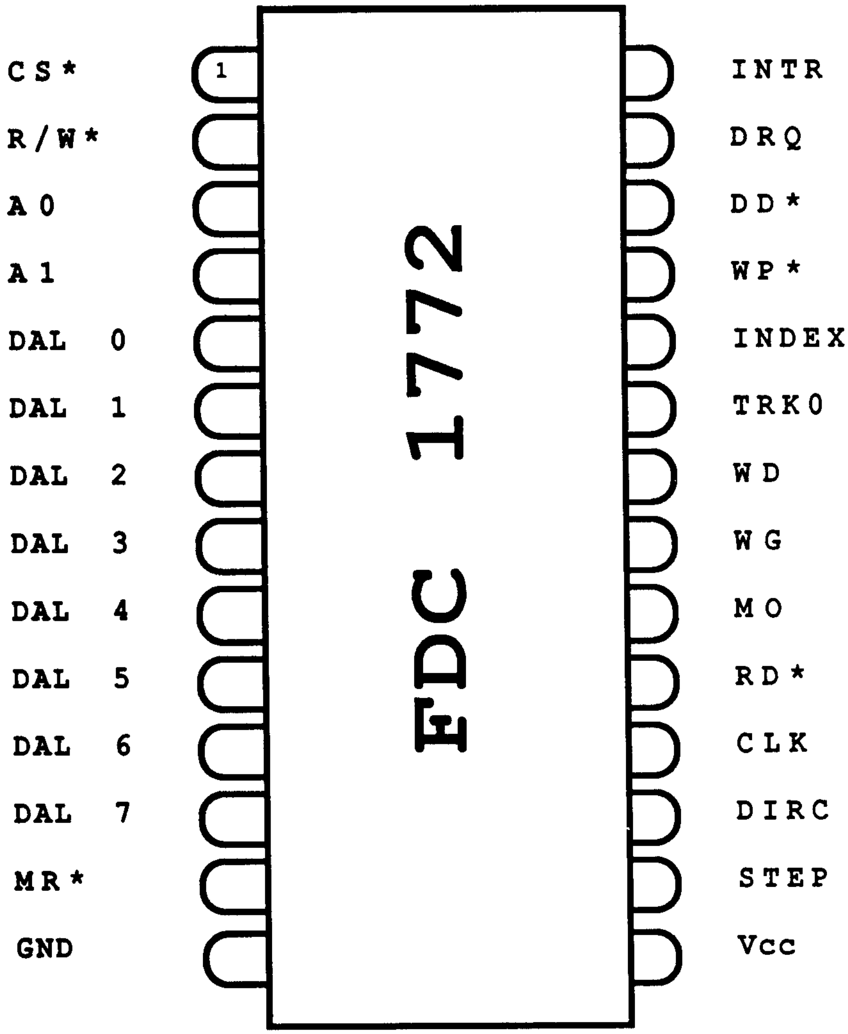
Ground connection.

MR:

Master reset. FDC reinitializes when this is low.

The second set are processor interface pins. These pins carry data between the processor and the FDC.

Figure 1.3-1 FDC 1772



D0-D7:

Eight-bit bi-directional bus; data, commands and status information go between FDC and system.

CS:

FDC can only access registers when this line is low.

R/W:

Read/Write. This pin states data direction. HIGH= read by FDC, LOW=write from FDC.

A0,A1:

These bits determine which register is accessed (in conjunction with R/W). The 1772 has a total of five registers which can both read and write to some degree. Other registers can only read OR write. Here is a table to show how the manufacturer designed them:

A1	A0	R/W=1	R/W=0
0	0	Status Reg.	Command Reg.
0	1	Track Reg.	Track Reg.
1	0	Sector Reg.	Sector Reg.
1	1	Data Reg.	Data Reg.

DRQ:

Data Request. When this output is high, either the data register is full (from reading), and must be "dumped", or the data register is empty (writing), and can be refilled. This connection aids the DMA operation of the FDC.

CLK:

Clock. The clock signal counts only to the processor bus. An input frequency of 8 mHz must be on, for the FDC's internal timing to work.

The third group of signals make up the floppy interface.

STEP:

Sends an impulse for every step of the head motor.

DIRC:

Direction. This connection decides the direction of the head; high moves the head towards center of the diskette.

RD:

Read Data. Reads data from the diskette. This information contains both timing and data impulses -- it is sent to the internal data separator for division.

MO:

Motor On. Controls the disk drive motor, which is automatically started during read/write/whatever operations.

WG:

Write Gate. WG will be low before writing to diskette. Write logic would be impossible without this line.

WD:

Write Data. Sends serial data flow as data and timing impulses.

TR00:

Track 00. This moves read/write head to track 00. TR00 would be low in this case.

IP:

Index Pulse. The index pulses mark the physical beginnings of every track on a diskette. When formatting a disk, the FDC marks the start of each track before formatting the disk.

WPRT:

Write Protect. If the diskette is write-protected, this input will react.

DDEN:

Double Density Enable. This signal is confined to floppy disk control; it allows you to switch between single-density and double-density formats.

1.3.2 1772 Registers

CR (Command Register):

Commands are written in this 8-bit register. Commands should only be written in CR when no other command is under execution. Although the FDC only understands 11 commands, we actually have a large number of possibilities for these commands (we'll talk about those later).

STR (Status Register):

Gives different conditions of the FDC, coded into individual bits. Command writing depends on the meaning of each bit. The status register can only be read.

TR (Track Register):

Contains the current position of the read/write head. Every movement of the head raises or lowers the value of TR appropriately. Some commands will read the contents of TR, along with information read from the disk. The result affects the Status Register. TR can be read/written.

SR (Sector Register):

SR contains the number of sectors desired from read/write operations. Like TR, it can be used for either operation.

DR (Data Register):

DR is used for writing data to/ reading data from diskette.

1.3.3 Programming the FDC

Programming this chip is no big deal for a system programmer. Direct (and in most cases, unnecessary) programming is made somewhat harder AND drastically simpler by the DMA chip. The 11 FDC commands are divided into four types.

Type	Function
1	Restore, look for track 00
1	Seek, look for a track
1	Step, a track in previous direction
1	Step In, move head one track in (toward disk hub)
1	Step Out, move head one track out (toward edge of disk)
2	Read Sector
2	Write Sector
3	Read Address, read ID
3	Read Track, read entire track
3	Write Track, write entire track (format)
4	Force Interrupt

Type 1 Commands

These commands position the read/write head. The bit patterns of these five commands look like this:

	BIT							
	7	6	5	4	3	2	1	0
Restore	0	0	0	0	H	V	R1	R0
Seek	0	0	0	1	H	V	R1	R0
Step	0	0	1	U	H	V	R1	R0
Step In	0	1	0	U	H	V	R1	R0
Step Out	0	1	1	U	H	V	R1	R0

All five commands have several variable bits; bits R0 and R1 give the time between two step impulses. The possible combinations are:

```
R1  R0  STEP RATE
0   0  2 milliseconds
0   1  3 milliseconds
1   0  5 milliseconds
1   1  6 milliseconds
```

These bits must be set by the command bytes to the disk drive. The V-bit is the so-called "verify flag". When set, the drive performs an automatic verify after every head movement. The H-bit contains the spin-up sequence. The system delays disk access until the disk motor has reached 300 rpm. If the H-bit is cleared, the FDC checks for activation of the motor-on pins. When the motor is off, this pin will be set high (motor on), and the FDC waits for 6 index impulses before executing the command. If the motor is already running, then there will be no waiting time.

The three different step commands have bit 4 designated a U- bit. Every step and change of the head appears here.

Type 2 Commands

These commands deal with reading and writing sectors. They also have individual bits with special meanings.

```
BIT          7  6  5  4  3  2  1  0
Read Sector  1  0  0  M  H  E  0  0
Write Sector 1  0  1  M  H  E  P  A0
```

The H-bit is the previously described start-up bit. When the E-bit is set, the FDC waits 30 milliseconds before starting the command. This delay is important for some disk drives, since it takes time for the head to change tracks. When the E-bit reads null, the command will run immediately.

The M-bit determines whether one or several sectors are read one after another. On a null reading, only one sector will be read from/written to. Multi-sector reading sets the bit, and the FDC increments the counter at each new sector read.

Bits 0 and 1 must be cleared for sector reading. Writing has its own special meaning: the A0 bit conveys to bit 0 whether a cleared or normal data

address mark is to be written. Most operating systems don't use this option (a normal data address mark is written).

The P-bit (bit 1) dictates whether pre-compensation for writing data is turned on or off. Pre-compensation is normally set on; it supplies a higher degree of protection to the inner tracks of a diskette.

Type 3 Commands

Read Address gives program information about the next ID field on the diskette. This ID field describes track, sector, disk side and sector length. Read Track gives all bytes written to a formatted diskette, and the data "between sectors". Write Track formats a track for data storage. Here are the bit patterns for these commands:

```
BIT             7 6 5 4 3 2 1 0
Read Address    1 1 0 0 H E 0 0
Read Track      1 1 1 0 H E 0 0
Write Track     1 1 1 1 H E P 0
```

The H- and E-bits also belong to the Type 2 command set (spin-up and head-settle time). The P-bit has the same function as in writing sectors.

Type 4 Commands

There's only one command in this set: Force Interrupt. This command can work with individual bits during another FDC command. When this command comes into play, whatever command was currently running is ended.

```
BIT             7  6  5  4  3  2  1  0
Force Interrupt 1  1  0  1  I3 I2 I1 I0
```

Bits I0-I3 present the conditions under which the interrupt is pressed. I0 and I1 have no meaning to the 1772, and remain low. If I2 is set, an interrupt will be produced with every index impulse. This allows for software controlled disk rotation. If I3 is set, an interrupt is forced immediately, and the currently-running command ends. When all bits are null, the command ends without interruption.

1.4 The MFP 68901

MFP is the abbreviation for Multi-Function Peripheral. This name is no exaggeration; wait until you see what it can do! Here's a brief list of the most noteworthy features:

8-bit parallel port
Data direction of every port bit is individually programmable
Port bits usable as interrupt input
16 possible interrupt sources
Four universal timers
Built-in serial interface

1.4.1 The 68901 Connections

The 48 pins of the MFP are set apart in function groups. The first function group is the power connection set:

GND, Vcc, CLK:

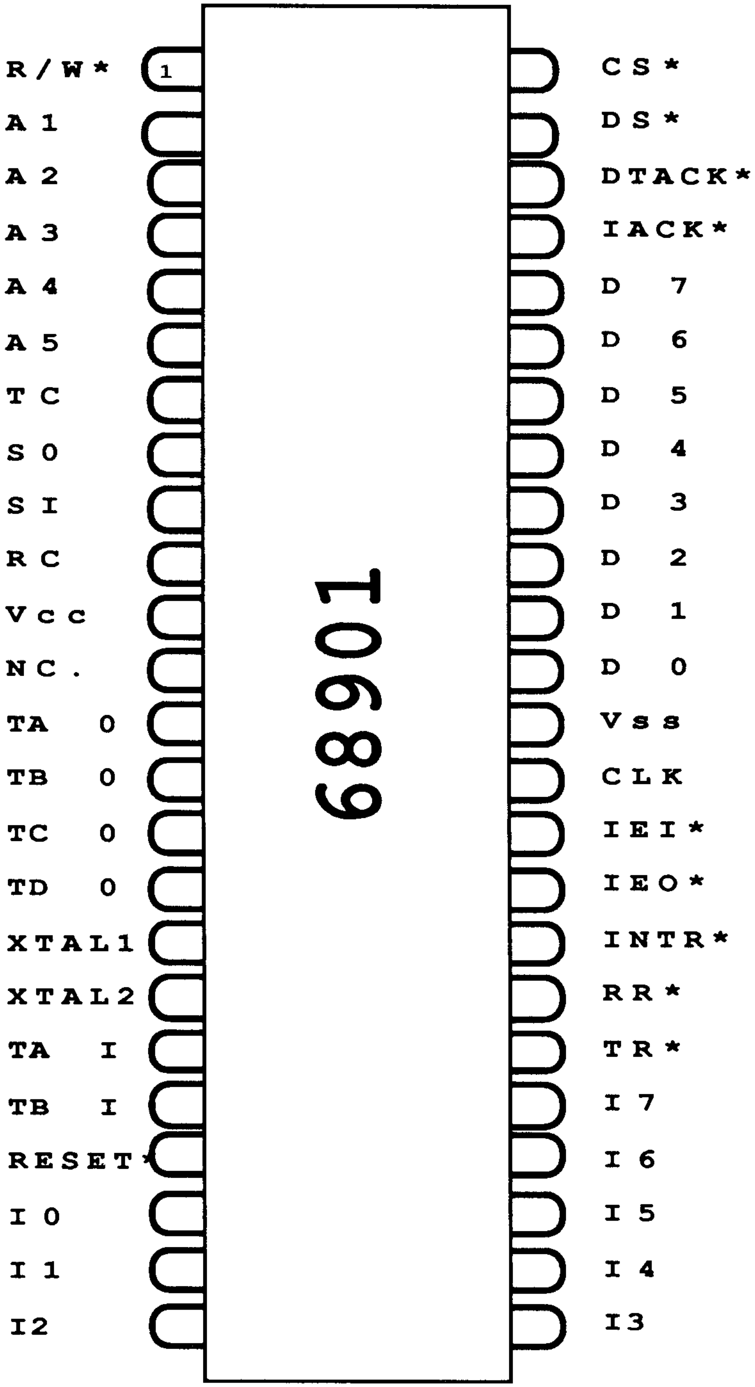
Vcc and GND carry voltage to and from the MFP. CLK is the clock input; this clock signal must not interfere with the system timer of the processor. The ST's MFP operates at a frequency of 4 mHz.

Communication with the data bus of the processor is maintained with D0-D7, DTACK, RS1-RS5 and RESET.

D0-D7:

These bi-directional pins normally work with the 8 lowest data bits of the 68000. It is also possible to connect with D8 through D15, but it's impossible to produce non-auto interrupts. Thus, interrupt vectors travel along the low order 8 data bits.

Figure 1.4-1 MFP 68901



CS (Chip Select):

This line is necessary to communication with the MFP. CS is active when low.

DS (Data Strobe):

This pin works with either LDS or UDS on the processor. Depending on the signal, MFP will operate either the lower or upper half of the data bus.

DTACK (Data Transfer ACKnoledge):

This signal shows the status of the bus cycle of the processor (read or write).

RS1-RS5 (Register Select):

These pins normally connect with to the bottom five address lines of the processor, and serve to choose from the 24 internal registers.

RESET:

If this pin is low for at least 2 microseconds, the MFP initializes. This occurs on power-up and a system reset.

The next group of signals cover interrupt connections (IRQ, IACK, IEI and IEO).

IRQ (Interrupt ReQuest):

IRQ will be low when an interrupt is triggered in the MFP. This informs the processor of interrupts.

IACK (Interrupt ACKnowledge):

On an interrupt (IRQ and IEI), the MFP sends a low signal over IACK and DS on the data lines. Since 16 different interrupt sources are available, this makes handling interrupts much simpler.

IEI, IEO (Interrupt Enable In/ Out):

These two lines permit daisy-chaining of several MFPs, and determine MFP priority by their positioning in this chain. IEI would work through the MFP with the highest priority. IEO of the second MFP would remain unswitched. On an interrupt, a signal is sent over IACK, and the first MFP in the chain will acknowledge with a high IEO.

Next, we'll look at the eight I/O lines.

IO0-7 (Input/Output):
These pins use one or all normal I/O lines. The data direction of each port bit is set up in a data direction register of its own. In addition, though, every port bit can be programmed to be an interrupt input.

The timer pins make up yet another group of connections:

XTAL1,2 (Timer Clock Crystal):
A quartz crystal can be connected to these lines to deliver a working frequency for the four timers.

TAI,TBI (Timer Input):
Timers A and B can not only be used as real counters differently from timers C and D with the frequency from XTAL1 and 2, but can also be set up for event counting and impulse width measurement. In both these cases, an external signal (Timer Input) must be used.

TAO,TBO,TCO,TDO (Timer Output):
Every timer can send out its status on each peg (from 01 to 00). Each impulse is equal to 01.

The second-to-last set of signals are the connections to the universal serial interface. The built-in full duplex of the MFP can be run synchronously or asynchronously, and in different sending and receiving baud rates.

SI (Serial Input):
An incoming bit current will go up the SI input.

SO (Serial Output):
Outgoing bit voltage (reverse of SI).

RC (Receiver Clock):
Transfer speed of incoming data is determined by the frequency of this input; the source of this signal can, for example, be one of the four timers.

TC (Transmitter Clock):
Similar to RC, but for adjusting the baud-rate of data being transmitted.

The final group of signals aren't used in the Atari ST. They are necessary when the serial interface is operated by the DMA.

RR (Receiver Ready):

This pin gives the status of the receiving data registers. If a character is completely received, this pin sends current.

TR (Transmitter Ready):

This line performs a similar function for the sender section of the serial interface. Low tells the DMA controller that a new character in the MFP must be sent.

1.4.2 The MFP Registers

As we've already mentioned, the 68901 has a total of 24 different registers. This large number, together with the logical arrangement, makes programming the MFP much easier.

Reg 1 GPIP, General Purpose I/O Interrupt Port

This is the data register for the 8-bit ports, where data from the port bits is sent and read.

Reg 2 AER, Active Edge Register

When port bits are used for input, this register dictates whether the interrupt will be a low-high- or high-low conversion. Zero is used in the high-low change, one for low-high.

Reg 3 DDR, Data Direction Register

We've already said that the data direction of individual port bits can be fixed by the user. When a DDR bit equals 0, the corresponding pin becomes an input, and 1 makes it an output. Port bit positions are influenced by AER and DDR bits.

Reg 4,5 IERA,IERB, Interrupt Enable Register

Every interrupt source of the MFP can be separately switched on and off. With a total of 16 sources, two 8-bit registers are needed to control them. If a 1 has been written to IERA or IERB, the corresponding channel is enabled (turned on). Conversely, a zero disables the channel. If it comes upon a closed channel caused by an interrupt, the MFP will completely ignore it. The following table shows which bit is coordinated with which interrupt occurrence:

```
IERA
Bit 7: I/O port bit 7 (highest priority)
Bit 6: I/O port bit 6
Bit 5: Timer A
Bit 4: Receive buffer full
Bit 3: Receive error
Bit 2: Sender buffer empty
Bit 1: Sender error
Bit 0: Timer B

IERB
Bit 7: I/O port bit 5
Bit 6: I/O port bit 4
Bit 5: Timer C
Bit 4: Timer D
Bit 3: I/O port bit 3
Bit 2: I/O port bit 2
Bit 1: I/O port bit 1
Bit 0: I/O port bit 0, lowest priority
```

This arrangement applies to the IP-, IM- and IS-registers discussed below.

Reg 6,7 IPRA,IPRB, Interrupt Pending Register

When an interrupt occurs on an open channel, the appropriate bit in the Interrupt Pending Register is set to 1. When working with a system that allows vector creation, this bit will be cleared when the MFP puts the vector number on the data bus. If this isn't possible, the IPR must be cleared using software. To clear a bit, a byte in the MFP will show the location of the specific bit.

The bit arrangement of the IPR bit arrangement is shown in the table for registers 4 and 5 (see above).

Reg 8,9 ISRA,ISRB,Interrupt In-Service Register

The function of these registers is somewhat complicated, and depends upon bit 3 of register 12. This bit is an S-bit, which determines whether the 68901 is working in "Software End-of-Interrupt" mode (SEI) or in "Automatic End-of-Interrupt" mode (AEI). AEI mode clears the IPR (Interrupt Pending Bit), when the processor gets the vector number from the MFP during an IACK cycle. The appropriate In-Service bit is cleared at the same time. Now a new interrupt can occur, even when the previous interrupt hasn't finished its work.

SEI mode sets the corresponding ISR-bit when the vector number of the interrupt is requested by the processor. At the interrupt routine's end, the bit designated within the MFP must be cleared. As long as the Interrupt In-Service bit is set, all interrupts of lower priority are masked out by the MFP. Once the Pending-bit of the active channel is cleared, the same sort of interrupt can occur a second time, and interrupts of lesser priority can occur as well.

Reg 10,11 IMRA,IMRB Interrupt Mask Register

Individual interrupt sources switched on by IER can be masked with the help of this register. That means that the interrupt is recognized from within and is signaled in the IPR, even if the IRQ line remains high.

Reg 12 VR Vector Register

In the cases of interrupts, the 68901 can generate a vector number corresponding to the interrupt source requested by the processor during an Interrupt Acknowledge Cycle. All 16 interrupt channels have their own vectors, with their priorities coded into the bottom four bits of the vector number (the upper four bits of the vector are copied from the vector register). These bits must be set into VR, therefore.

Bit 3 of VR is the previously mentioned S-bit. If this bit is set (like in the ST), then the MFP operates in "Software End-of-Interrupt" mode; a cleared bit puts the system into "Automatic End-of-Interrupt" mode.

Reg 13,14 TACR,TBCR Timer A/B Control Register

Before proceeding with these registers, we should talk for a moment about the timer. Timers A and B are both identical. Every timer consists of a data register, a programmable feature and an 8-bit count-down counter. Contents of the counters will decrease by one every impulse. When the counter stands at 01, the next impulse changes the corresponding timer to the output of its pins. At the same time, the value of the timer data register is loaded into the timer. If this channel is set by the IER bit, the interrupt will be requested. The source of the timer beats will usually be those quartz frequencies from XTAL1 and 2. This operating mode is called delay mode, and is available to timers C and D.

Timers A and B can also be fed external impulses using timer inputs TAI and TBI (in event count mode). The maximum frequency on timer inputs should not surpass 1/4 of the MFP's operating frequency (that is, 1 mHz).

Another peculiarity of this operating mode is the fact that the timer inputs for the interrupts are I/O pins 13 and 14. By programming the corresponding bits in the AER, a pin-jump can be used by the timer inputs to request an interrupt. TAI is joined with pin 13, TBI by pin 14. Pins 13 and 14 can also be used as I/O lines without interrupt capability.

Timers A and B have yet a third operating mode (pulse-length measurement). This is similar to Delay Mode, with the difference that the timer can be turned on and off with TAI and TBI. Also, when pins 13 and 14 are used, the AER-bits can determine whether the timer inputs are high or low. If, say, AER-bit 4 is set, the counter works when TAI is high. When TAI changes to low, an interrupt is created.

Now we come to TACR and TBCR. Both registers only use the fifth through eighth bits. Bits 0 to 3 determine the operating mode of each timer:

BIT 3	2	1	0	Function
0	0	0	0	Timer stop, no function executed
0	0	0	1	Delay mode, subdivider divides by 4
0	0	1	0	Delay mode, subdivider divides by 10
0	0	1	1	Delay mode, subdivider divides by 16
0	0	1	1	Delay mode, subdivider divides by 16
0	1	0	0	Delay mode, subdivider divides by 50
0	1	0	1	Delay mode, subdivider divides by 64
0	1	1	0	Delay mode, subdivider divides by 100
0	1	1	1	Delay mode, subdivider divides by 200
1	0	0	0	Event Count Mode
1	0	0	1	Pulse extension mode,subdivider divides by 4
1	0	1	0	Pulse extension mode,subdivider divides by 10
1	0	1	1	Pulse extension mode,subdivider divides by 16
1	1	0	0	Pulse extension mode,subdivider divides by 50
1	1	0	1	Pulse extension mode,subdivider divides by 64
1	1	1	0	Pulse extension mode,subdivider divides by 100
1	1	1	1	Pulse extension mode,subdivider divides by 200

Bit 4 of the Timer Control Register has a particular function. This bit can produce a low reading for the timer being used with it at any time. However, it will immediately go high when the timer runs.

Reg 15 TCDCR Timers C and D Control Register

Timers C and D are available only in delay mode; thus, one byte controls both timers. The control information is programmed into the lower three bits of the nibbles (four- bit halves). Bits 0 and 2 arrange Timer D, Timer C is influenced by bits 4 and 6. Bits 3 and 7 in this register have no function.

Bit	2	1	0	Function - Timer D
Bit	6	5	4	Function - Timer C
	0	0	0	Timer Stop
	0	0	1	Delay Mode, division by 4
	0	1	0	Delay Mode, division by 10
	0	1	1	Delay Mode, division by 16
	1	0	0	Delay Mode, division by 50
	1	0	1	Delay Mode, division by 64
	1	1	0	Delay Mode, division by 100
	1	1	1	Delay Mode, division by 200

Reg 16-19 TADR,TBDR,TCDR,TDDR Timer Data Registers

The four Timer Data Registers are loaded with a value from the counter. When a condition of 01 is reached, an impulse occurs. A continuous countdown will stem from this value.

Reg 20 SCR Synchronous Character Register

A value will be written to this register by synchronous data transfer, so that the receiver of the data will be alerted. When synchronous mode is chosen, all characters received will be stored in the SCR, after first being put into the receive buffer.

Reg 21 UCR,USART Control Register

USART is short for Universal Synchronous/Asynchronous Receiver/Transmitter. The UCR allows you to set all the operating parameters for the interfaces. Parameters can also be coded in with the timers.

```
Bit 0      : unused
Bit 1      : 0=Odd parity
             1=Even parity

Bit 2      : 0=No parity (bit 1 is ignored)
             1=Parity according to bit 1

Bits 3,4   : These bis control the number of
             start- and stopbits and the
             format desired.
   Bit    4 3 Start Stop Format
          0 0   0    0   Synchronous
          0 1   1    1   Asynchronous
          1 0   1    1,5 Asynchronous
          1 1   1    2   Asynchronous

Bits 5,6   :  These bits give the
              "wordlength" of the data bits
              to be transferred.
   Bits 6 5 Word length
        0 0 8 bits
        0 1 7 bits
        1 0 6 bits
        1 1 5 bits
```

```
Bit 7        :   0=Frequency from TC and RC
                        directly used as transfer
                        frequency (used only for
                        synchronous transfer)
                        1=Frequency in TC and RC
                        internally divided by 16.
```

Reg 22 RSR Receiver Status Register

The RSR gives information concerning the conditions of all receivers. Again, the different conditions are coded into individual bits.

Bit 0 Receiver Enable Bit

When this bit is cleared, receipt is immediately turned off. All flags in RSR are automatically cleared. A set bit means that the receiver is behaving normally.

Bit 1 Synchronous Strip Enable

This bit allows synchronous data transfer to determine whether or not a character in the SCR is identical to a character in the receive buffer.

Bit 2 Match/Character in Progress

When in synchronous transfer format, this bit signals that a character identical with the SCR byte would be received. In asynchronous mode, this bit is set as soon as the startbit is recognized. A stopbit automatically clears this bit.

Bit 3 Found - Search/Break Detected

This bit is set in synchronous transfer format, when a character received coincides with one stored in the SCR. This condition can be treated as an interrupt over the receiver's error channel. Asynchronous mode will cause the bit to set when a BREAK is received. The break condition is fulfilled when only zeroes are received following a startbit. To distinguish between a BREAK from a "real" null, this line should be low.

Bit 4 Frame Error

A frame error occurs when a byte received is not a null, but the stopbit of the byte IS a null.

Bit 5 Parity Error

The condition of this bit gives information as to whether parity on the last received character was correct. If the parity test is off, the PE bit is untouched.

Bit 6 Overrun Error

This bit will be set when a complete character is in the receiver floating range but not read into the receive buffer. This error can be operated as an interrupt.

Bit 7 Buffer Full

This bit is set when a character is transferred from the floating register to the receive buffer. As soon as the processor reads the byte, the bit is cleared.

Reg 23 TSR Transmitter Status Register

Whereas the RSR sends receiver information, the TSR handles transmission information.

Bit 0 Transmitter Enable

The sending section is completely shut off when this bit is cleared. At the same time the End-bit is cleared and the UE-bit is set (see below). The output to the receiver is set in the corresponding H- and L-bits.

Bits 1,2 High- and Low-bit

These bits let the programmer decide which mode of output the switched-off transmitter will take on. If both bits are cleared,the output is high. High-bit only will create high output; low-bit, low output. Both bits on will switch on loop-back-mode. This state loops the output from the transmitter with receiver input. The output itself is on the high-pin.

Bit 3 Break

The break-bit has no function in synchronous data transfer. In asynchronous mode, though, a break condition is sent when the bit is set.

Bit 4 End of Transmission

If the sender is switched off during running transmission, the end-bit will be set as soon as the current character has been sent in its entirety. When no character is sent, the bit is immediately set.

Bit 5 Auto Turnaround

When this bit is set, the receiver is automatically switched on when the transmitter is off, and a character will eventually be sent.

Bit 6 Underrun Error

This bit is switched on when a character in the sender floating register will be sent, before a new character is written into the send buffer.

Bit 7 Buffer Empty

This bit will be set when a character from the send buffer will be transferred to the floating register. The bit is cleared when new data is written to the send buffer.

Reg 24 UDR, USART Data Register

Send/receive data is sent over this register. Writing sends data in the send buffer, reading gives you the contents of the receive buffer.

1.5 The 6850 ACIAs

ACIA is short for "Asynchronous Communications Interface Adapter". This 24-pin IC has all the components necessary for operating a serial interface, as well as error-recognizing and data-formatting capabilities. Originally for 6800-based computers, this chip can be easily tailored for 6502 and 68000 systems. The ST has two of these chips. One of them communicates with the keyboard, mouse, joystick ports, and runs the clock. Keyboard data travels over a serial interface to the 68000 chip. The second ACIA is used for operating the MIDI interface.

Parameter changes in the keyboard ACIA are not recommended: The connection between keyboard and ST can be easily disrupted. The MIDI interface is another story, though -- we can create all sorts of practical applications. Incidentally, nowhere else has it been mentioned that the MIDI connections can be used for other purposes. One idea would be to use the MIDI interfaces of several STs to link them together (for schools or offices, for example).

1.5.1 The Pins of the 6850

For those of you readers who aren't very well-acquainted with the principles of serial data transfer, we've included some fairly detailed descriptions in the pin layout which follows.

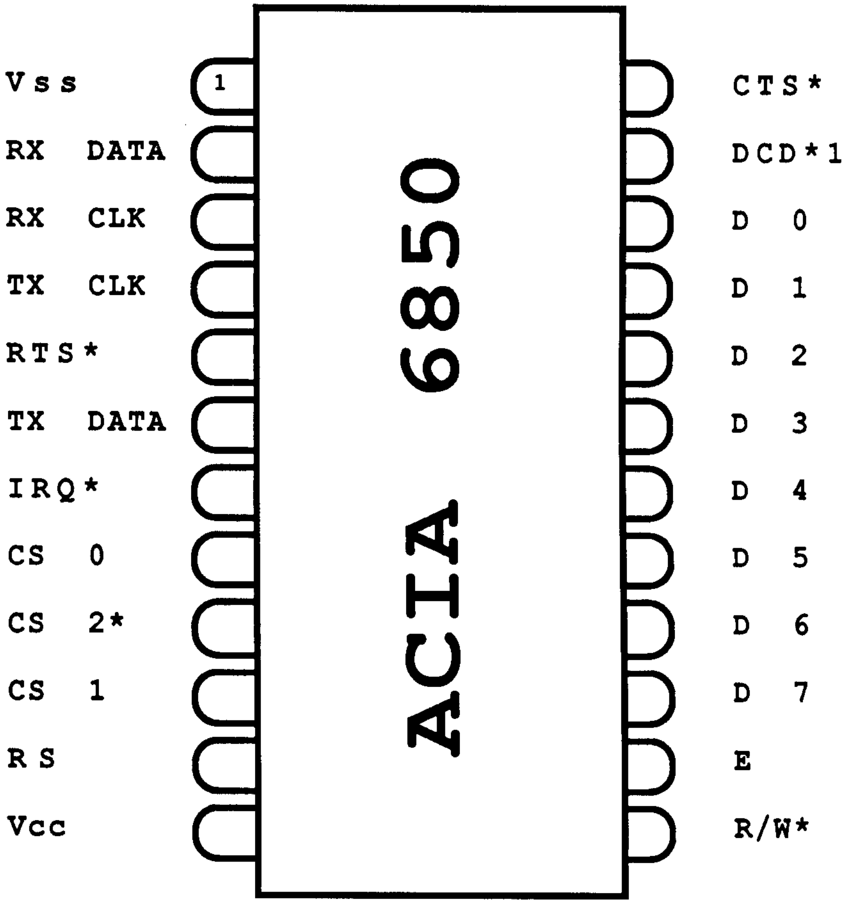
Vss

This connection is the "ground wire" of the IC.

RX DATA Receive Data

This pin receives data; a start-bit must precede the least significant data-bit before receipt.

Figure 1.5-1 ACIA 6850



RX CLK Receive Clock

This pin signal determines baud-rate (speed at which the data is received), and is synchronize to the incoming data. The frequency of RX CLK is patterned after the desired transfer speed and after the internally programmed division rate.

TX CLK Transmitter Clock

Like RX CLK, only used for transmission speed.

RTS Request To Send

This output signals the processor whether the 6850 is low or high; mostly used for controlling data transfer. A low output will, for example, signal a modem that the computer is ready to transmit.

TX DATA Transmitter Data

This pin sends data bit-wise (serially) from the computer.

IRQ Interrupt Request

Different circumstances set this pin low, signaling the 68000 processor. Possible conditions include completed transmission or receipt of a character.

CS 0,1,2 Chip Select

These three lines are needed for ACIA selection. The relatively high number of CS signals help minimize the amount of hardware needed for address decoding, particularly in smaller computer systems.

RS Register Select

This signal communicates with internal registers, and works closely with the R/W signal. We shall talk about these registers later.

Vcc Voltage

This pin is required of all ICs -- this pin gets an operating voltage of 5V.

R/W Read/Write

This tells the processor the "direction" of data traveling through the ACIA. A high signal tells the processor to read data, and low writes data in the 6850.

E Enable

The E-signal determines the time of reading/writing. All read/write processes with this signal must be synchronous.

D0 - D7 Data

These data lines are connected to those of the 68000. Until the ACIA is accessed, these bidirectional lines are all high.

DCD Data Carrier Detect

A modem control signal, which detects incoming data. When DCD is high, serial data cannot be received.

CTS Clear To Send

CTS answers the computer on the signal RTS. Data transmission is possible only when this pin is low.

1.5.2 The Registers of the 6850

The 6850 has four different registers. Two of these are read only. Two of them are write only. These registers are distinguished by R/W and RS, after the table below:

R/W	RS	Register	Access
0	0	Control Register	write
0	1	Sender Register	write
1	0	Status Register	read
1	1	Receive Register	read

The sender/receiver registers (also known as the RX- and TX- buffers) are for data transfer. When receiving is possible, the incoming bits are put in a shift register. Once the specified number of bits has arrived, the contents of the shift register are transferred to the TX buffer. The sender works in much the same way, only in the reverse direction (RX buffer to sender shift register).

The Control Register

The eight-bit control register determines internal operations. To solve the problem of controlling diverse functions with one byte, single bits are set up as below:

CR 0,1

These bits determine by which factor the transmitter and receiver clock will be divided. These bits also are joined with a master reset function. The 6850 has no separate reset line, so it must be accomplished through software.

CR1	CR0	
0	0	RXCLK/TXCLK without division
0	1	RXCLK/TXCLK by 16 (for MIDI)
1	0	RXCLK/TXCLK by 64 (for keyboard)
1	1	Master RESET

CR 2,3,4

These so-called Word Select bits tell whether 7 or 8 data-bits are involved; whether 1 or 2 stop-bits are transferred; and the type of parity.

CR4	CR3	CR2	
0	0	0	7 databits, 2 stopbits, even parity
0	0	1	7 databits, 2 stopbits, odd parity
0	1	0	7 databits, 1 stopbit, even parity
0	1	1	7 databits, 1 stopbit, odd parity
1	0	0	8 databits, 2 stopbit, no parity
1	0	1	8 databits, 1 stopbit, no parity
1	1	0	8 databits, 1 stopbit, even parity
1	1	1	8 databits, 1 stopbit, odd parity

CR 6,5

These Transmitter Control bits set the RTS output pin, and allow or prevent an interrupt through the ACIA when the send register is emptied. Also, BREAK signals can be sent over the serial output by this line. A BREAK signal is nothing more than a long sequence of null bits.

CR6	CR5	
0	0	RTS low, transmitter IRQ disabled
0	1	RTS low, transmitter IRQ enabled
1	0	RTS high, transmitter IRQ disabled
1	1	RTS low, transmitter IRQ disabled, BREAK sent

CR 7

The Receiver Interrupt Enable bit determines whether the receiver interrupt will be on. An interrupt can be caused by the DCD line changing from low to high, or by the receiver data buffer filling. Besides that, an interrupt can occur from an OVERRUN (a received character isn't properly read from the processor).

CR7	
0	Interrupt disabled
1	Interrupt enabled

The Status Register

The Status Register gives information about the status of the chip. It also has its information coded into individual bytes.

SR0

When this bit is high, the RX data register is full. The byte must be read before a new character can be received (otherwise an OVERRUN happens).

SR1

This bit reflects the status of the TX data buffer. An empty register sets the bit.

SR2

A low-high change on pin DCD sets SR2. If the receiver interrupt is allowable, the IRQ will be cancelled. The bit is cleared when the status register and the receiver register are read. This also cancels the IRQ. SR2 register remains high if the signal on the DCD pin is still high; SR2 registers low if DCD becomes low.

SR3

This line shows the status of CTS. This signal cannot be altered by a master reset, or by ACIA programming.

SR4

Shows "Frame errors". Frame errors are when no stop-bit is recognized in receiver switching. It can be set with every new character.

SR5

This bit displays the previously mentioned OVERRUN condition. SR5 is reset when the RX buffer is read.

SR6

This bit recognizes whether the parity of a received character is correct. The bit is set on an error.

SR 7

This signals the state of the IRQ pins; this bit makes it possible to switch several IRQ lines on one interrupt input. In cases where an interrupt is program-generated, SR7 can tell which IC cut off the interrupt.

The ACIAs in the ST

The ACIAs have lots of extras unnecessary to the ST. In fact, CTS, DCD and RTS are not connected.

The keyboard ACIA lies at the addresses $FFFC00 and $FFFC02. Built-in parameters are: 8-bit word, 1 stopbit, no parity, 7812.5 baud (500 kHz/64).

The parameters are the same for the MIDI chip, EXCEPT for the baud rate, which runs at 31250 baud (500 kHz/16).

1.6 The YM-2149 Sound Generator

The Yamaha YM-2149, a PSG (programmable sound generator) in the same family as the General Instruments AY-3-8190, is a first-class sound synthesis chip. It was developed to produce sound for arcade games. The PSG also has remarkable capabilities for generating/altering sounds. Additionally, the PSG can be easily controlled by joysticks, the computer keyboard, or external keyboard switching. The PSG has two bidirectional 8-bit parallel ports. Here's some general data on the YM-2149:

- three independently programmable tone generators
- a programmable noise generator
- complete software-controlled analog output
- programmable mixer for tone/noise
- 15 logarithmically raised volume levels
- programmable envelopes (ASDR)
- two bidirectional 8-bit data ports
- TTL-compatible
- simple 5-volt power

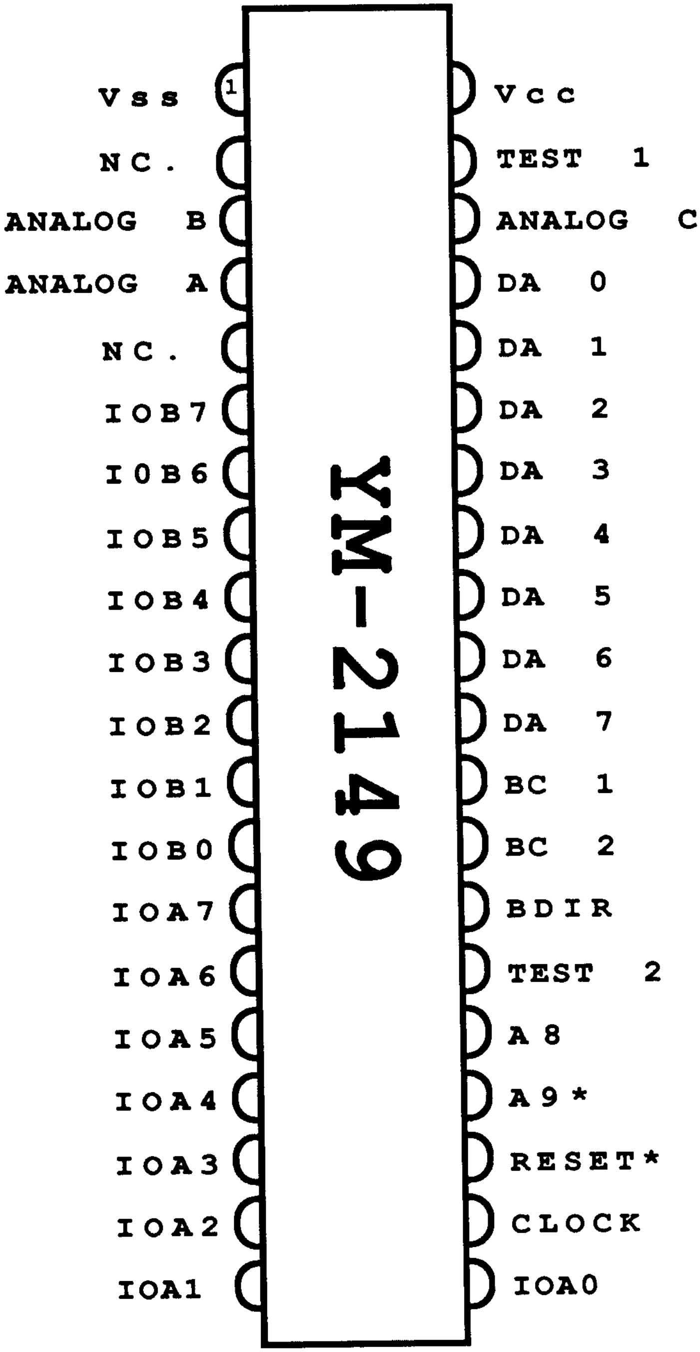
The YM-2149 has a total of 16 registers. All sound capabilities are controlled by these registers.

The PSG has several "functional blocks" each with its own job. The tone generator block produces a square-wave sound by means of a time signal. The noise generator block produces a frequency-modulated square-wave signal, whose pulse-width simulates a noise generator. The mixer couples the three tone generators' output with the noise signal. The channels may be coupled by programming.

The amplitude control block controls the output volume of the three channels with the volume registers; or creates envelopes (Attack, Decay, Sustain, Release, or ADSR), which controls the volume and alters the sound quality.

The D/A converter translates the volume and envelope information into digital form, for external use. Finally one function block controls the two I/O ports.

Figure 1.6-1 Sound chip YM-2149



1.6.1 Sound Chip Pins

Vss:

This is the PSG ground connection.

NC.:

Not used.

ANALOG B:

This is the channel B output. Maximum output voltage is 1 vss.

ANALOG A:

Works like pin 3, but for channel A.

NC.:

Not used.

IOB7 - 0:

The IOB connections make up one of the two 8-bit ports on the chip. These pins can be used for either input or output. Mixed operation (input and output combined) is impossible within one port, however both ports are independent of one another.

IOA7 - 0:

Like IOB, but for port A.

CLOCK:

All tone frequencies are divided by this signal. This signal operates at a frequency between 1 and 2 mHz.

RESET:

A low signal from this pin resets all internal registers. Without a reset, random numbers exist in all registers, the result being a rather unmusical "racket".

A9:

This pin acts as a chip select-signal. When it is low, the PSG registers are ready for communication.

A8:

Similar to A9, only it is active when high.

TEST2:

Test2 is used for testing in the factory, and is unused in normal operation.

BDIR & BC1,2:

The BDIR (Bus DIRection), BC1 and BC2 (Bus Control) pins control the PSG's register access.

BDIR	BC2	BC1	PSG function
0	0	0	Inactive
0	0	1	Latch address
0	1	0	Inactive
0	1	1	Read from PSG
1	0	0	Latch address
1	0	1	Inactive
1	1	0	Write to PSG
1	1	1	Latch address

Only four of these combinations are of any use to us; those with a 5+ voltage running over BC2. So, here's what we have left:

BDIR	BC1	Function
0	0	Inactive, PSG data bus high
0	1	Read PSG registers
1	0	Write PSG registers
1	1	Latch, write register number(s)

DA0 - 7:

These pins connect the sound chip to the processor, through the data bus. The identifier DA means that both data and (register) addresses can be sent over these lines.

ANALOG C:

Works with channel C (see ANALOG B, above).

TEST1:

See TEST2.

Vcc:

+5 volt pin.

1.6.2 The 2149 Registers and their Functions

Now let's look at the functions of the individual registers. One point of interest: the contents of the address register remain unaltered until reprogrammed. You can use the same data over and over, without having to send that data again.

Reg 0,1:

These register determine the period length, and the pitch of ANALOG A. Not all 16 bits are used here; the eight bits of register 0 (set frequency) and the four lowest bits of register 1 (control step size). The lower the 12-bit value in the register, the higher the tone.

Reg 2,3:

Same as registers 0 and 1, only for channel B.

Reg 4,5:

Same as registers 0 and 1, only for channel C.

Reg 6:

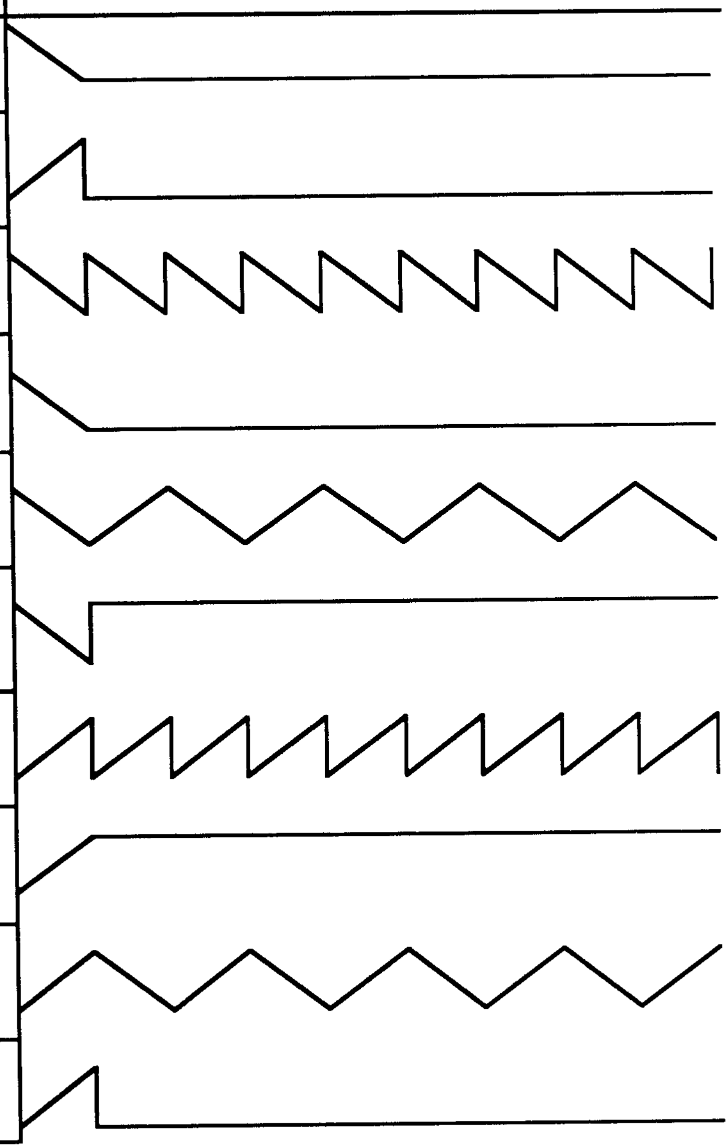
The five lowest bits of this register control the noise generator. Again, the smaller the value, the higher the noise "pitch".

Reg 7:

```
Bit 0:Channel A tone on/off        0=on /1=off
Bit 1:Channel B tone on/off        0=on /1=off
Bit 2:Channel C tone on/off        0=on /1=off
Bit 3:Channel A noise on/off       0=on /1=off
Bit 4:Channel B noise on/off       0=on /1=off
Bit 5:Channel C noise on/off       0=on /1=off
Bit 6:Port A in/output             0=in /1=out
Bit 7:Port B in/output             0=in /1=out
```

Figure 1.6-2 Envelopes of the PSG

REG 15 B3 CONTINUE	B2 ATTACK	B1 ALTERNATE	B0 HOLD
0	0	–	–
0	1	–	–
1	0	0	0
1	0	0	1
1	0	1	0
1	0	1	1
1	1	0	0
1	1	0	1
1	1	1	0
1	1	1	1



Reg 8:

Bits 0-3 of this register control the signal volume of channel A. When bit 4 is set, the envelope register is being used and the contents of bits 0-3 are ignored.

Reg 9:

Same as register 8, but for channel B.

Reg 10:

Same as register 8, but for channel C.

Reg 11,12:

The contents of register 11 are the low-byte and the contents of register 12 are the high-byte of the sustain.

Reg 13:

Bits 0-3 determine the waveform of the envelope generator. The possible envelopes are pictured in Figure 1.6-2.

Reg 14,15:

These registers comprise the two 8-bit ports. Register 14 is connected to Port A and register 15 is connected to Port B. If these ports are programmed as output (bits 7 and 8 of register 7) then values may be sent through these registers.

1.7 I/O Register Layout in the ST

The entire I/O range (all peripheral ICs and other registers) is controlled by a 32K address register -- $FF8000 - $FFFFFF. Below is a complete table of the different registers. CAUTION: The I/O section can be accessed only in supervisor mode. Any access in user mode results in a bus-error.

```
$FF8000   Memory configuration
$FF8200   Video display register
$FF8400   Reserved
$FF8600   DMA/disk controller
$FF8800   Sound chip
$FFFA00   MFP 68901
$FFFC00   ACIAs for MIDI and keyboard
```

The addresses given refer only to the start of each register, and supply no hint as to the size of each. More detailed information follows.

$FF8000 Memory Configuration

There is a single 8-bit register at $FF8001 in which the memory configuration is set up (four lowest bits). The MMU-IC is designed for maximum versatility within the ST. It lets you use three different types of memory expansion chips: 64K, 256K, and the 1M chips. Since all of these ICs are bit-oriented instead of byte-oriented, 16 memory chips of each type are required for memory expansion. The identifier for 16 such chips (regardless of memory capacity) is BANK. So, expansion is possible to 128 Kbyte, 512 Kbyte or even 2 Megabytes.

MMU can control two banks at once, using the RAS- and CAS- signals. The table on the next page shows the possible combinations:

$FF8001	Bit	Memory configuration	
	3-0	Bank 0	Bank 1
	0000	128K	128K
	0001	128K	512K
	0010	128K	2 M
	0011	reserved	
	0100	512K	128K
	0101	512K	512K
	0100	512K	2 M,normally reserved
	0100	reserved	
	1000	2M	128K
	1001	2M	512K
	1010	2M	2M
	1011	reserved	
	11XX	reserved	

The memory configuration can be read from or written to.

$FF8200 Video Display Register

This register is the storage area that determines the resolution and the color palette of the video display.

```
$FF8201   8-bit  Screen memory position (high-byte)
$FF8203   8-bit  Screen memory position (low-byte)
```

These two read/write registers are located at the beginning of the 32K video RAM.

In order to relocate video RAM, another register is used. This register is three bytes long and is located at $FF8205. Video RAM can be relocated in 256-byte increments. Normally the starting address of video RAM is $78000.

```
$FF8205   8-bit  Video address pointer (high-byte)
$FF8207   8-bit  Video address pointer (mid-byte)
$FF8209   8-bit  Video address pointer (low-byte)
```

These three registers are read only. Every three microseconds, the contents of these registers are incremented by 2.

```
$FF820A BIT       Synchronization mode
        1 0
        : :-- 0=internal,1=external synchronization
        :---- 0=60 Hz, 1=50Hz screen frequency
```

The bottom two bits of this register control synchronization mode; the remaining bits are unused. If bit 0 is set, the HSync and VSync impulses are shut off, which allows for screen synchronization from external sources (monitor jack). This offers new realm of possibilities in video, synchronization of your ST and a video camera, for example.

Bit 1 of the sync-mode register handles the screen frequency. This bit is useful only in the two "lowest" resolutions. High-res operation puts the ST at a 70 Hz screen frequency.

Sync mode can be read/written.

```
$FF8240   16-bit    Color palette register 0
$FF8242   16-bit    Color palette register 1
   :         :                :
   :         :      Color palette registers 2-13
   :         :                :
$FF825C   16-bit    Color palette register 14
$FF825E   16-bit    Color palette register 15
```

Although the ST has a total of 512 colors, only 16 different colors can be displayed on the screen at one time. The reason for this is that the user has 16 color pens on screen, and each can be one of 512 colors. The color palette registers represent these pens. All 16 registers contain 9 bits which affect the color:

```
FEDCBA9876543210
.....XXX.XXX.XXX
```

The bits marked X control the registers. Bits 0-2 adjust the shade of blue desired; 4-6, green hue; and 8-A, red. The higher the value in these three bits, the more intense the resulting color.

Middle resolution (640 X 200 points) offers four different colors; colors 4 through 15 are ignored by the palette registers.

When you want the maximum of 16 colors, it's best to zero-out the contents of the palette registers.

High-res (640 X 400 points) gives you a choice on only one "color"; bit 0 of palette register 0 is set to the background color. If the bit is cleared, then the text is black on a light background. A set bit reverses the screen (light characters, black background). The color register is a read/write register.

```
$FF8260    Bit  Resolution
           1 0
           0 0  320 X 200 points, four focal planes
           0 1  640 X 200 points, two focal planes
           1 0  640 X 400 points, one focal planes
```

This register sets up the appropriate hardware for the graphic resolution desired.

$FF8600 DMA/Disk Controller

```
$FF8600               reserved
$FF8602               reserved

$FF8604    16-bit     FDC access/sector count
```

The lowest 8 bits access the FDC registers. The upper 8 bits contain no information, and consistently read 1. Which register of the FDC is used depends upon the information in the DMA mode control register at $FF8606. The FDC can also be accessed indirectly.

The sector count-register under $FF8604 can be accessed when the appropriate bit in the DMA control register is set. The contents of these addresses are both read/write.

```
$FF8606    16-bit     DMA mode/status
```

When this register is read, the DMA status is found in the lower three bits of the register.

```
Bit 0  0=no error, 1=DMA error
Bit 1  0=sector count = null, 1=sector count<>null
Bit 2  Condition of FDC DATA REQUEST signal
```

Write access to this address controls the DMA mode register.

```
  Bit 0     unused
  Bit 1     0=pin A0 is low
            1=pin A0 is high
  Bit 2     0=pin A1 is low
            1=pin A1 is high
  Bit 3     0=FDC access
            1=HDC access
  Bit 4     0=access to FDC register
            1=access to sector count register
  Bit 5     0, reserved
  Bit 6     0=DMA on
            1=no DMA
  Bit 7     0=hard disk controller access (HDC)
            1=FDC access
  Bit 8     0=read FDC/HDC registers
            1=write to FDC/HDC registers

$FF8609   8-bit     DMA basis and counter high-byte
$FF860B   8-bit     DMA basis and counter mid-byte
$FF860D   8-bit     DMA basis and counter low-byte
```

DMA transfer will tell the hardware at which address the data is to be moved. The initialization of the three registers must begin with the low-byte of the address, then mid-byte, then high-byte.

$FF8800 Sound Chip

The YM-2149 has 16 internal registers which can't be directly addressed. Instead, the number for the desired register is loaded into the select register. The chosen registers can be read/write, until a new register number is written to the PSG.

```
$FF8800   8-bit     Read data/Register select
```

Reading this address gives you the last register used (normally port A), by which disk drive is selected. This can be accomplished with write-protect signals, although these protected contents can be accessed by another register. Port A is used for multiple control functions, while port B is the printer data port.

```
PORT A
  Bit 0     Page-choice signal for double-sided
            floppy drive
  Bit 1     Drive select signal -- floppy drive 0
  Bit 2     Drive select signal -- floppy drive 1
  Bit 3     RS-232 RTS-output
  Bit 4     RS-232 DTR output
  Bit 5     Centronics strobe
  Bit 6     Freely usable output (monitor jack)
  Bit 7     reserved
```

When $FF8800 is written to, the select register of the PSG is alerted. The information in the bottom four bits are then considered as register numbers. The necessary four-bit number serves for writing to the PSG.

```
$FF8802   8-bit     Write data
```

Attempting to read this address after writing to it will give you $FF only, while BDIR and BC1 are nulls.

Writing register numbers and data can be performed with a single MOVE instruction.

$FFFA00 MFP 68901

The MFP's 24 registers are found at odd addresses from $FFFA01-$FFFA2F:

```
$FFFA01   8-bit     Parallel port
$FFFA03   8-bit     Active Edge register
$FFFA05   8-bit     Data direction
$FFFA07   8-bit     Interrupt enable A
$FFFA09   8-bit     Interrupt enable B
$FFFA0B   8-bit     Interrupt pending A
$FFFA0D   8-bit     Interrupt pending B
$FFFA0F   8-bit     Interrupt in-service A
$FFFA11   8-bit     Interrupt in-service B
$FFFA13   8-bit     Interrupt mask A
$FFFA15   8-bit     Interrupt mask B
$FFFA17   8-bit     Vector register
$FFFA19   8-bit     Timer A control
$FFFA1B   8-bit     Timer B control
```

```
$FFFA1D   8-bit    Timer C & D control
$FFFA1F   8-bit    Timer A data
$FFFA21   8-bit    Timer B data
$FFFA23   8-bit    Timer C data
$FFFA25   8-bit    Timer D data
$FFFA27   8-bit    Sync character
$FFFA29   8-bit    USART control
$FFFA2B   8-bit    Receiver status
$FFFA2D   8-bit    Transmitter status
$FFFA2F   8-bit    USART data
```

See the chapter on the MFP for details on the individual registers.

```
I/O Port
Bit 0     Centronics busy
Bit 1     RS-232 data carrier detect - input
Bit 2     RS-232 clear to send - input
Bit 3     reserved
Bit 4     keyboard and MIDI interrupt
Bit 5     FDC and HDC interrupt
Bit 6     RS-232 ring indicator
Bit 7     Monochrome monitor detect
```

Timers A and B each have an input which can be used by external timer control, or send a time impulse from an external source. Timer A is unused in the ST, which means that the input is always available, but it isn't connected to the user port, so the Centronics busy pin is connected instead. You can use it for your own purposes.

Timer B is used for counting screen lines in conjunction with DE (Display Enable).

The timer outputs in A-C are unused. Timer D, on the other hand, sends the timing signal for the MFP's built-in serial interface.

$FFFC00 Keyboard and MIDI ACIAs

The communications between the ST, the keyboard, and musical instruments are handled by two registers in the ACIAs.

```
$FFFC00   8-bit     Keyboard ACIA control
$FFFC02   8-bit     Keyboard ACIA data
$FFFC04   8-bit     MIDI ACIA control
$FFFC06   8-bit     MIDI ACIA data
```

Figure 1.7-1 I/O Assignments

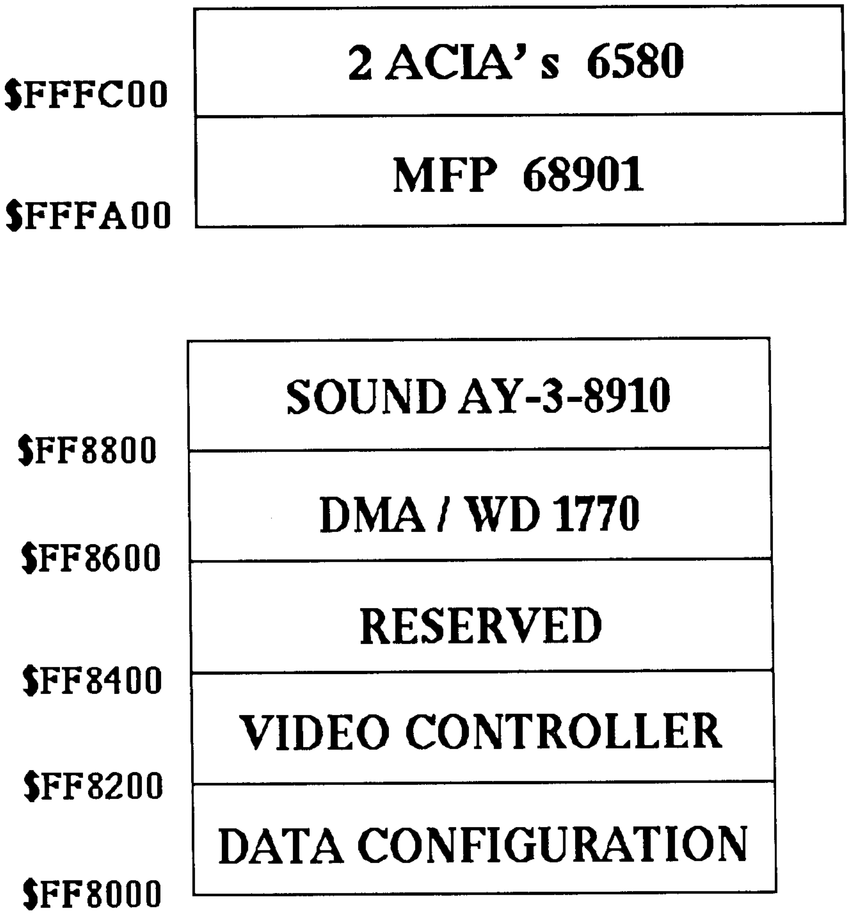
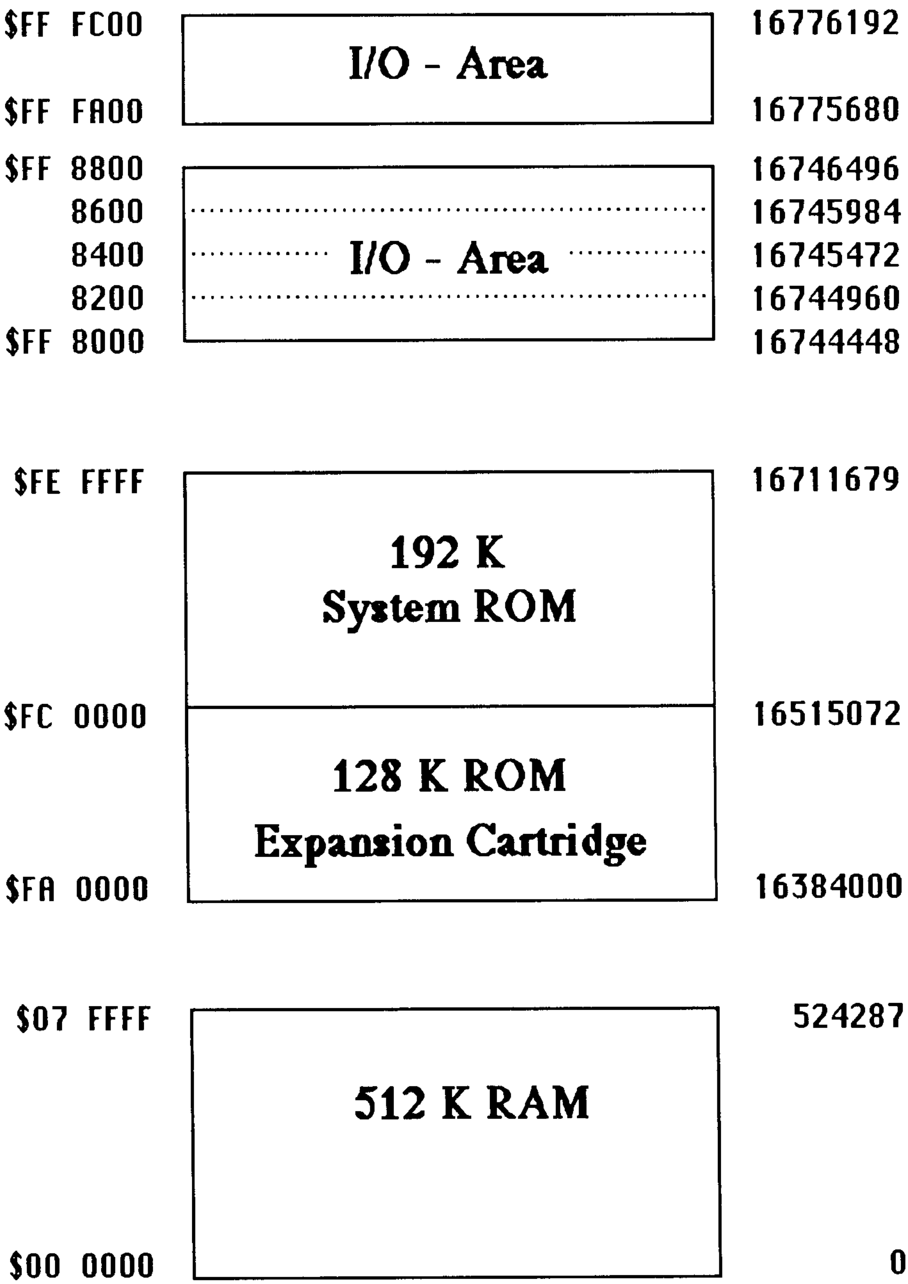
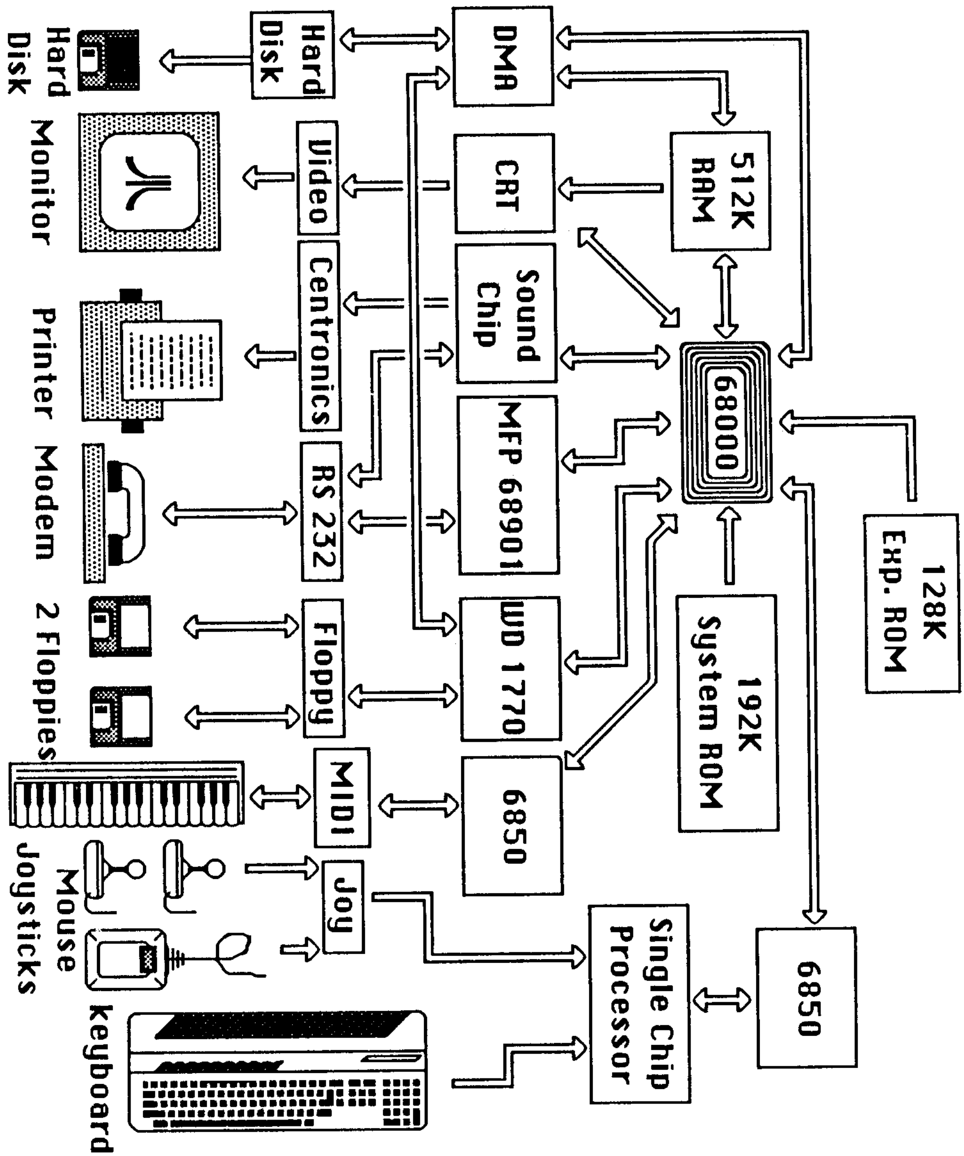


Figure 1.7-2 Memory Map of the ATARI ST



BLOCK DIAGRAM of the ATARI ST



Chapter Two

The Interfaces

The Interfaces

2.1 The Keyboard

Do you think it's really necessary to give a detailed report on something as trivial as the keyboard, since keyboards all function the same way? Actually the title should read "Keyboard Systems" or something similar. The keyboard is controlled by its own processor. You will soon see how this affects the assembly language programmer.

The keyboard processor is single-chip computer (controller) from the 6800 family, the 6301. Single chip means that everything needed for operation is found on a single IC. In actuality, there are some passive components in the keyboard circuit along with the 6301.

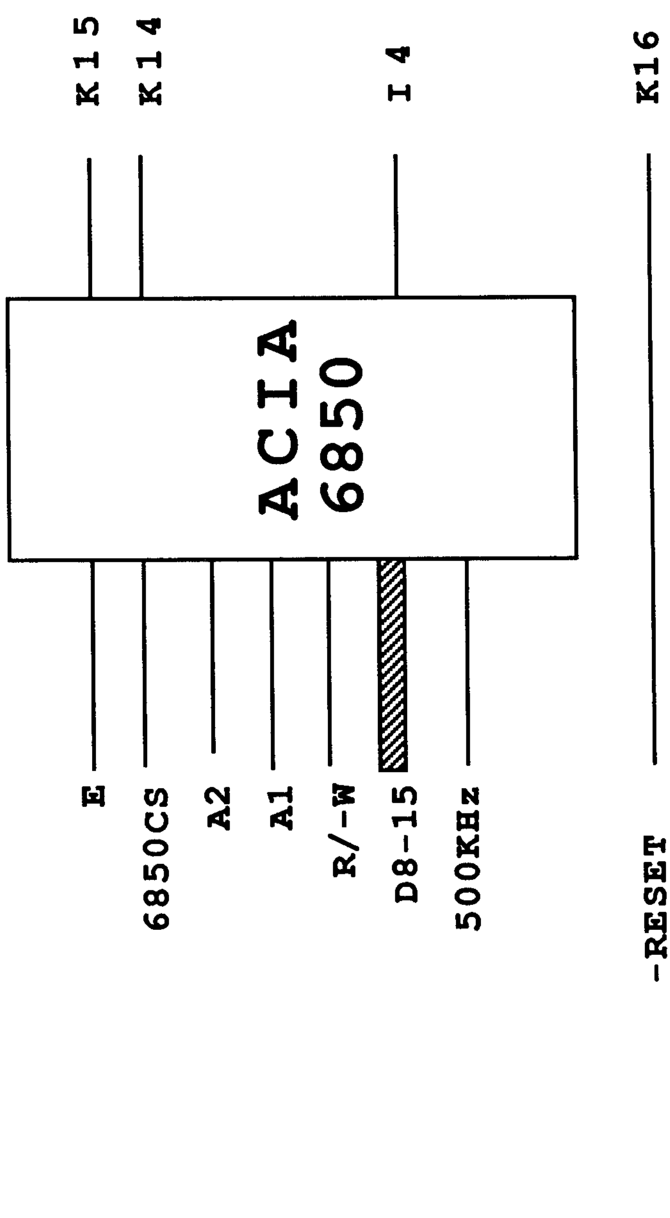
The 6301 has ROM, RAM, some I/O lines, and even a serial interface on the chip. The serial interface handles the traffic to and from the main board.

The advantage of this design is easy to see. The main computer is not burdened by having to continually poll the keyboard. Instead it can dedicate itself completely to processing your programs. The keyboard processor notifies the system if an event occurs that the operating system should be aware of.

The 6301 is not only responsible for the relatively boring task of reading the keyboard, however. It also takes care of the rather complicated tasks required in connection with the mouse. The main processor is then fed simply the new X and Y coordinates when the mouse is moved. Naturally, anything to do with the joysticks is also taken care of by the keyboard controller.

In addition, this controller contains a real-time clock which counts in one-second increments.

Figure 2.1-1 6850 Interface to 68000



In Figure 2.1-1 is an overview of the interface to the 68000. As you see, the main processors is burdened as little as possible. The ACIA 6850 ensures that it is disturbed only when a byte has actually been completely received from the keyboard. The ACIA, by the way, can be accessed at addresses $FFFC00 (control register) and $FFFC02 (data register). The individual connection to the keyboard takes place over lines K14 and K15. K indicates the plug connection by which the keyboard is connected to the main board.

The signal that the ACIA has received a byte is first sent over line 14 to the MFP 68901 which then generates an interrupt to the 68000. The clock frequency of 500KHz comes from GLUE. From this results the "odd" transfer rate of 7812.5 baud.

In case you were surprised that data can also be sent *to* the keyboard processor, you will find the solution to the puzzle in Chapter 2.1.2.

The block diagram of the keyboard circuit is found in Figure 2.1-2. The function is as simple as the figure is easy to read. The processor has 4K of ROM available. The 128 bytes of RAM is comparatively small, but it is used only as a buffer and for storing pointers and counters.

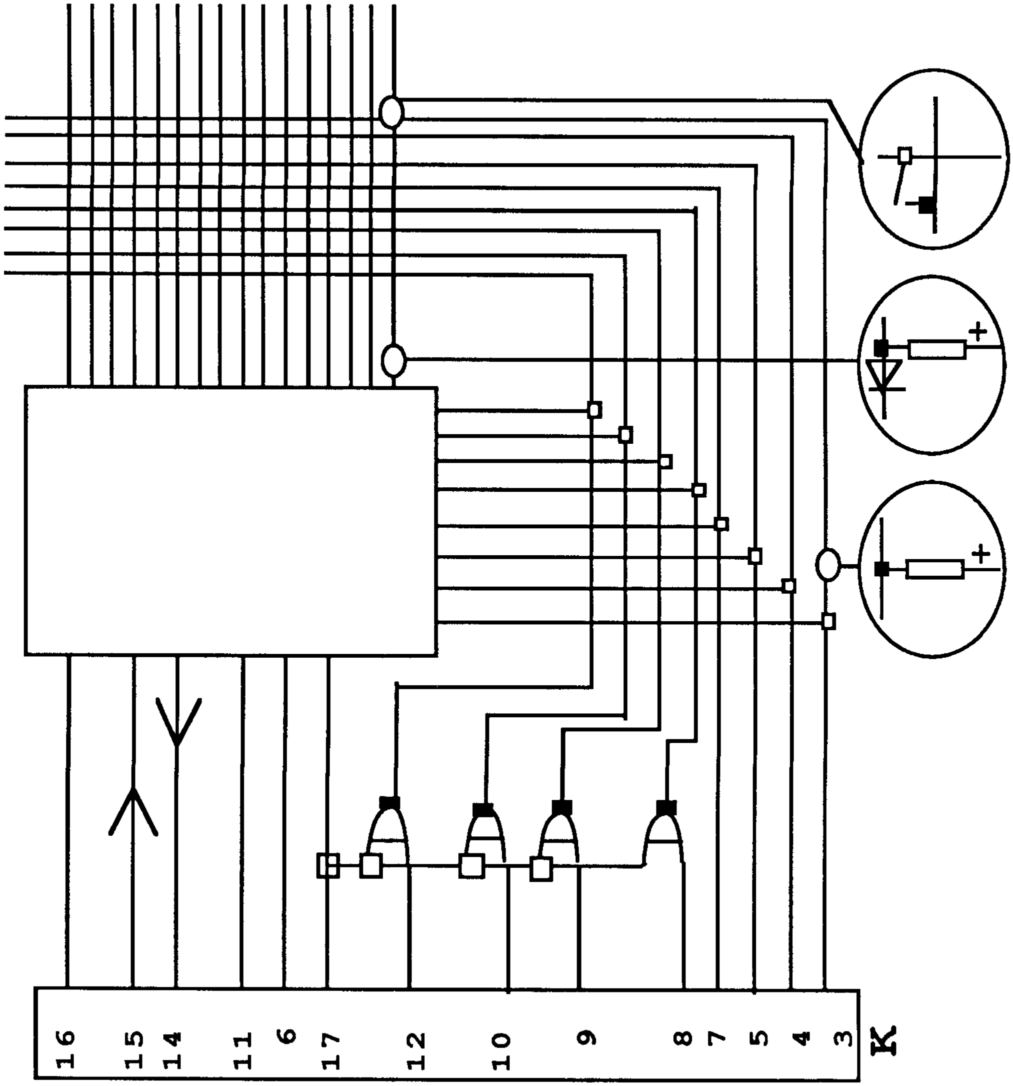
The lines designated with K are again the plug connections assigned to the main board. With few exceptions, the connections for the joystick and mouse are also put through. K16 is the reset line from the 68000. K15 carries the send data from the 6850, K14 the send data from the 6301.

The I/O ports 1(0-7), 3(1-7), and 4(0-7) are responsible for reading the keyboard matrix. One line from ports 3 and 4 is pulled low in a cycle. The state of port 1 is the checked. If a key is pressed, the low signal comes through on port 1.

Each key can be identified from the combination of value placed on ports 3 and 4 and the value read from port 1.

If none of the lines of Port 3 and 4 are placed low and a bit of port 1 still equals zero, a joystick is active on the outer connector 1. The data from outer connector 0, to which a mouse or a joystick can be connected, does not come through by chance since it must first be switched through the NAND gate with port 2 (bit 0). The buttons on the mouse or the joystick then arrive at port 2 (1 and 2).

Figure 2.1-2 Block Diagram of Keyboard Circuit



The assignments of the K lines to the signal names on the outer connector are found in the next section.

The 6301 processor is completely independent, but it can also be configured so that it works with an external ROM. Some of the port lines are then reconfigured to act as address lines. The configuration the processor assumes (one of eight possibilities) depends on the logical signal placed on port 2 (bits 0-2) during the reset cycle. All three lines high puts the processor in mode 7, the right one for the task intended here. But bits 1 and 2 depend on the buttons on the mouse. If you leave the mouse alone while powering-up, everything will be in order. If you hold the two buttons down, however, the processor enters mode 1 and makes a magnificent belly-flop, since the hardware for this operating mode is not provided. You notice this by the fact that the mouse cursor does not move on the screen if you move the mouse. Only the reset button will restore the processor.

2.1.1 The Mouse

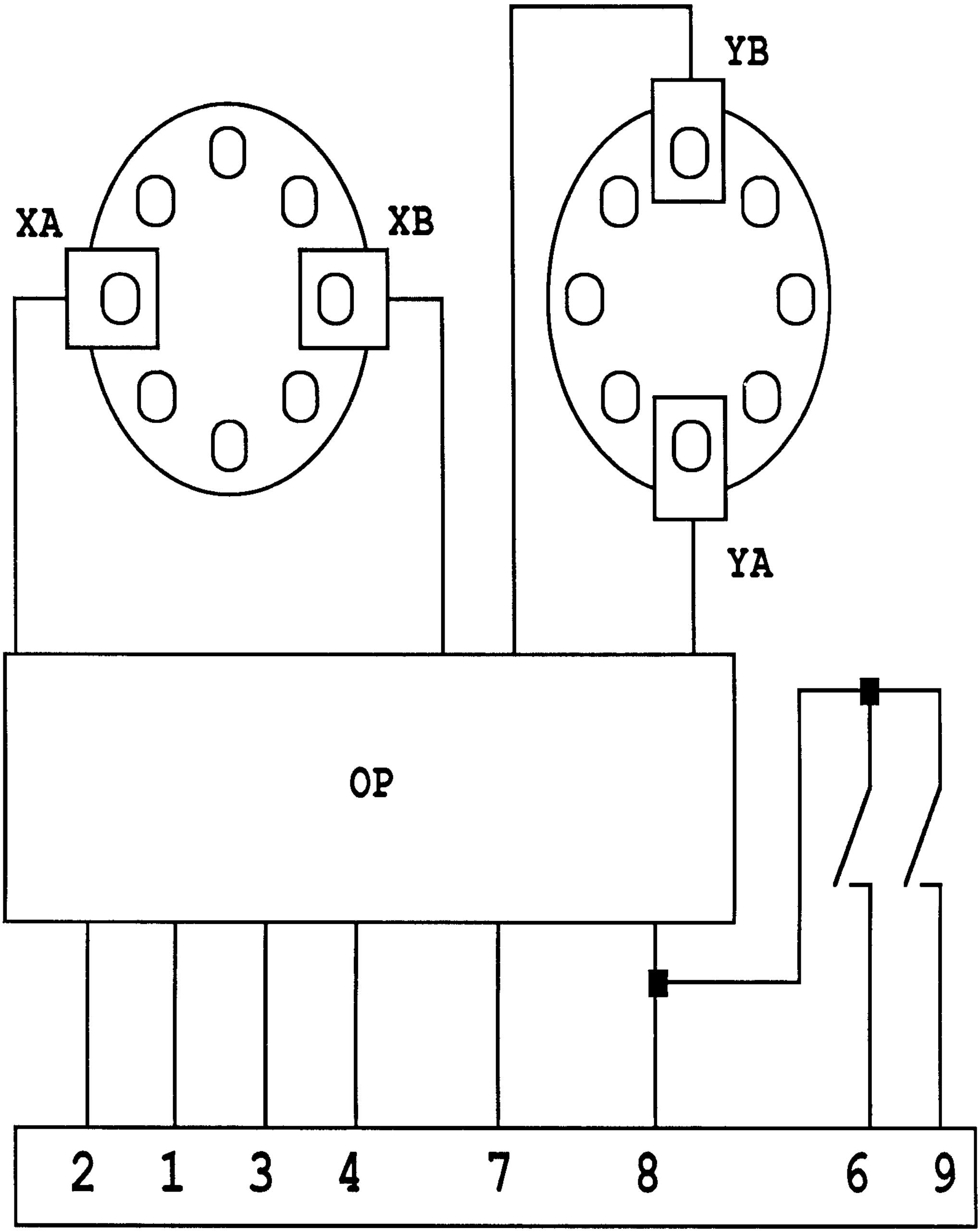
The construction of this little device is quite simple, but effective. Essentially, it consists of four light barriers, two encoder wheels, and a drive mechanism.

The task of the mouse is to give the computer information about its movements. This information consists of the components: direction on the X-axis, direction on the Y-axis, and the path traveled on each axis.

In order to do this, the rubber-covered ball visible from the outside drives two encoder wheels whose drive axes are at angle of 90 degrees to each other. The one or the other axis rotates more or less, forwards or backwards, depending on the direction the mouse is moved.

It is no problem to determine the absolute movement on each axis. The encoder wheels alternately interrupt the light barriers. One need only count the pulses from each wheel to be informed about the path traveled on each axis.

Figure 2.1.1-1 The Mouse



It is more difficult when the direction of movement is also required. The designers of the mouse used a convenient trick for this. There are not one, but two light barriers on each encoder wheel. They are arranged such that they are not shielded by the wheel at precisely the same time, but one shortly after the other. This arrangement may not be so clear in Figure 2.1.1-1, so we'll explain it in more detail The direction can be determined by noticing which of the two light barriers is interrupted first. This is why the pulses from both light barriers are sent out, making a total of four. Corresponding to their significance they carry the names XA, XB, YA, YB.

The two contacts which you see on the picture represent the two buttons.

The large box on the picture is a quad operational amplifier which converts the rather rough light-barrier pulses into square wave signals.

In Figure 2.1.1-2 is the layout of the control port on the computer, as you see it when you look at it from the outside. The designation behind the slash applies when a joystick is connected and the number in parentheses is the pin number of the keyboard connector.

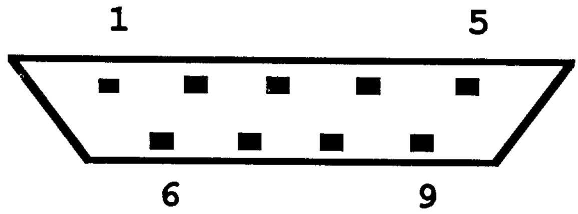
Port 0

1	XB/UP	(K12)
2	XA/DOWN	(K10)
3	YA/LEFT	(K9)
4	YB/RIGHT	(K8)
6	LEFT BUTTON/FIRE	(K11)
7	+5V	(K13)
8	GND	(K1)
9	RIGHT BUTTON	(K6)

Port 1

1	UP	(K7)
2	DOWN	(K5)
3	LEFT	(K4)
4	RIGHT	(K3)
5	Port 0 enable	(K17)
6	FIRE	(K6)
7	+5V	(K13)
8	GND	(K1)

Figure 2.1.1-2 Mouse control port



2.1.2 Keyboard commands

The keyboard processor "understands" some commands pertaining to such things as how the mouse is to be handled, etc. You can set the clock time, read the internal memory, and so on. You can find an application example in the assembly language listing on page 80 (after command $21).

The "normal" action of the processor consists of keeping an eye on the keyboard and announcing each keypress. This is done by outputting the number of the key when the key is pressed. When the key is released the number is set again, but with bit 7 set. The result of this is that no key numbers greater than 127 are possible. You can find the assignment of the key numbers to the keys at the end of this section in figure 2.1.2-1. In reality these numbers only go up to 117 because values from $F6 up are reserved for other purposes. There must be a way to pass more information than just key numbers to the main processor, information such as the clock time or the current position of the mouse. This cannot be handled in a single byte but only in something called a package, so the bytes at $F6 signal the start of a package. Which header comes before which package is explained along with the individual commands.

A command to the keyboard processor consists of the command code (a byte) and any parameters required. The following description is sorted according to command bytes.

$07
Returns the result of pressing one of the two mouse buttons. A parameter byte with the following format is required:

```
Bit 0   =1: The absolute position is returned when a
            mouse button is pressed. Bit 2 must =0.
Bit 1   =1: The absolute position is returned when a
            mouse button is released. Bit 2 must =0.
Bit 2   =1: The mouse buttons are treated like
            normal keys. The left button is key
            number $74, the right is $75.
Bits 3-7    must always be zero.
```

$08
Returns the relative mouse position from now on. This command tells the keyboard processor to automatically return the relative position (the distance from the previous position) whenever the mouse is moved. A movement is given when the number of encoder wheel pulses has reached a given threshold. See also $0B. A relative mouse package looks like this:

```
1 byte   Header in range $F8-$FB. The two lowest
         bits of the header indicate the condition
         of the two mouse buttons.
1 byte   Relative X-position (signed!)
1 byte   Relative Y-position (signed!)
```

If the relative position changes substantially between two packages so that the distance can no longer be expressed in one byte, another package is automatically created which makes up for the remainder.

$09
Returns the absolute mouse position from now on. This command also sets the coordinate maximums. The internal coordinate pointers are at the same time set to zero. The following parameters are required:

```
1 word   Maximum X-coordinate
1 word   Maximum Y-coordinate
```

Mouse movements under the zero point or over the maximums are not returned.

$0A
With this command it is possible to get the key numbers of the cursor keys instead of the coordinates. A mouse movement then appears to the operating system as if the corresponding cursor keys had been pressed. These parameters are necessary:

```
1 byte Number of pulses (X) after which the key
       number for cursor left (or right) will be
       sent.
1 byte Number of pulses (Y) after which the key
       number for cursor up (or down) will be sent.
```

$0B

This command sets the trigger threshold, above which movements will be announced. A certain number of encoder pulses elapse before a package is sent. This functions only in the relative operating mode. The following are the parameters:

```
1 byte    Threshold in X-direction
1 byte    Threshold in Y-direction
```

$0C

Scale mouse. Here is determined how many encoder pulses will go by before the coordinate counter is changed by 1. This command is valid only in the absolute. The following parameters are required:

```
1 byte    X scaling
1 byte    Y scaling
```

$0D

Read absolute mouse position. No parameters are required, but a package of the following form is sent:

```
1 byte    Header = $F7
1 byte    Button status
      Bit 0 = 1: Right button was pressed since the
                 last read
      Bit 1 = 1: Right button was not pressed
      Bit 2 = 1: Left button was pressed since the
                 last read
      Bit 3 = 1: Left button was not pressed
```

From this strange arrangement you can determine that the state of a button has changed since the last read if the two bits pertaining to it are zero.

```
1 word Absolute X-coordinate
1 word Absolute Y-coordinate
```

$0E
Set the internal coordinate counter. The following parameters are required:

```
1 byte    =0 as fill byte
1 word    X-coordinate
1 word    Y-coordinate
```

$0F
Set the origin for the Y-axis is down (next to the user).

$10
Set the origin for the Y-axis is up.

$11
The data transfer to the main processor is permitted again (see $13). Any command other than $13 will also restart the transfer.

$12
Turn mouse off. Any mouse-mode command ($08, $09, $0A) turns the mouse back on. If the mouse is in mode $0A, this command has no effect.

$13
Stop data transfer to main processor.
NOTE: Mouse movements and key presses will be stored as long as the small buffer of the 6301 allows. Actions beyond the capacity of the buffer will be lost.

$14
Every joystick movement is automatically returned. The packages sent have the following format:

```
1 byte    Header = $FE or $FF for joystick 0/1
1 byte    Bits 0-3 for the position (a bit for each
          direction), bit 7 for the button
```

$15
End the automatic-return mode for the joystick. When needed, a package must be requested with $16.

$16
Read joystick. After this command the keyboard sends a package as described above.

$17

Joystick duration message. One parameter is required.

```
1 byte    Time between two messages in 1/100 sec.
```

From this point on, packages of the following form are sent continuously (as long as no other mode is selected):

```
1 byte    Bit 0 for the button on joystick 1, bit 1
          for that of joystick 0
1 byte    Bits 0-3 for the position of joystick 1,
          bits 4-7 for the position of joystick 0
```

NOTE: The read interval should not be shorter than the transfer channel needs to send the two bytes of the package.

$18

Fire button duration message. The condition of the button in joystick 1 (!) is continually tested and the result packed into a byte. This means that a message byte contains 8 such tests, whereby bit 7 is the most recent. The keyboard controller determines the time between byte fetches by the main processor. This time is divided into eight equal intervals in which the button is polled. The polling then takes place as regularly as possible. This mode remains active until another command is received.

$19

Cursor key simulation mode for joystick 0 (!). The current position of the joystick is sent to the main processor as if the corresponding cursor keys had been pressed (as often as necessary). To avoid having to explain the same things for the following parameters, here are the most important: All times are assumed to be in tenths of seconds. R indicates the time, when reached, cursor clicks will be sent in intervals of T. After this the interval is V. If R=0, only V is responsible for the interval. Naturally, this mechanism comes into play only when the joystick is held in the same position for longer than T or R.

```
1 byte    RX
1 byte    RY
1 byte    TX
1 byte    TY
1 byte    VX
1 byte    VY
```

$1A
Turn off joysticks. Any other joystick command turns them on again.

$1B
Set clock time. This command sets the internal real-time clock in the keyboard processor. The values are passed in packed BCD, meaning a digit 0-9 for each half byte, yielding a two-digit decimal number per byte. The following parameters are necessary:

```
1 byte    Year, two digit (85, 86, etc.)
1 byte    Month, two digit (12, 01, etc.)
1 byte    Day, two digit (31,01,02, etc.)
1 byte    Hours, two digit
1 byte    Minutes, two digit
1 byte    Seconds, two digit
```

Any half byte which does not contain a valid BCD digit (such as F) is ignored. This makes it possible to change just part of the date or clock time.

$1C
Read clock time. After receiving this command the keyboard processor returns a package having the same format as the one described above. A header is added to the package, however, having the value $FC.

$20
Load memory. The internal memory of the keyboard processor (naturally only the RAM in the range $80 to $FF makes sense) can be written with this command. It is not clear to us of what use this is since according to our investigations (we have disassembled the operating system of the 6301), no RAM is available to be used as desired. Perhaps certain parameters can be changed in this manner which are not accessible through "legal" means. Here are the parameters:

```
1 word    Start address
1 byte    Number of bytes (max. 128)
Data bytes (corresponding to the number)
```

The interval at which the data bytes will be sent must be less than 20 msec.

$21

Read memory. This command is the opposite of $20. These parameters are required:

```
1 word    Address at which to read
```

A package having the following format is returned:

```
1 byte   Header 1 =$F6. This is the status header
         which precedes all packages containing any
         operating conditions of the keyboard
         processor. We will come to the general
         status messages shortly.
1 byte   Header 2 =$20 as indicator that this
         package carries the memory contents.
6 bytes  Memory contents starting with the address
         given in the command.
```

Here is a small program which we used to read the ROM in the 6301 and output it to a printer. Here you also see how the status packages arrive from the keyboard. These are normally thrown away by the 68000 operating system. Section 3.1 contains information about the GEMDOS and XBIOS calls used.

```
                    prt     equ     0
                    chout   equ     3
                    gemdos  equ     1
                    bios    equ     13
                    xbios   equ     14
                    stvec   equ     12
                    rdm     equ     $21
                    wrkbd   equ     25
                    kbdvec  equ     34
                    term    equ     0
start:
        move.w  #kbdvec,-(a7)
        trap    #xbios
        addq.l  #2,a7
        move.l  d0,a0
        lea     keyin,a1
        move.l  d0,savea
        move.l  stvec(a0),save
```

```
        move.l   a1,stvec(a0)
        move.w   #$f000,d4              Starting address
loop:
        move.w   d4,tbuf+1              Current address
        bsr      keyout
wait:
        cmpi.b   rbuf
        beq      wait
        moveq.w  #5,d6
        bsr      bufout
        addq.w   #6,d4                  Ending address?
        bmi      loop
        bra      exit
bufout:
        lea      rbuf+2,a4
bytout:
        move.b   (a4)+,d0
        bsr      hexout
        dbra     d6,bytout
        rts
hexout:
        movea.w  d0,a1
        lsr.b    #4,d0
        andi.w   #15,d0
        lea      table,a3
        move.b   0(a3,d0),d2
        lsl.w    #8,d2
        move.w   a1,d0
        andi.w   #15,d0
        move.b   0(a3,d0),d2
        move.w   d2,d0
        move.w   d2,-(a7)
        lsr.w    #8,d0
        bsr      chrout
        move.w   (a7)+,d0
        bsr      chrout
        move.b   #" ",d0
chrout:
        move.w   d0,-(a7)
        move.w   #prt,-(a7)
        move.w   #chout,-(a7)
        trap     #bios
        addq.l   #6,a7
        rts
exit:
        movea    savea,a0
        move.l   save,stvec(a0)
```

```
        move.w  #term,-(a7)
        trap    #gemdos
keyout:
        move.b  rbuf
        pea     tbuf
        move.w  #2,-(a7)
        move.w  #wrkbd,-(a7)
        trap    #xbios
        addq.l  #8,a7
        rts
keyin:
        moveq   #7,d0
        lea     rbuf,a1
repin:
        move.b  (a0)+,(a1)+
        dbra    d0,repin
        rts
table:
        dc.b    "0123456789ABCDEF"

        rbuf:   ds.b    8
        save    ds.l    1
        savea   ds.l    1
        dummy   ds.b    1
        tbuf    dc.b    rdm
        ds.b    2
        .end
```

$22

Execute routine. With this command you can execute a subroutine in the 6301. Naturally, you must know exactly what it does and where it is located, so long as you have not transferred it yourself to RAM with $20 (assuming you found some free space). The only required parameters are:

```
1 word  Start address
```

Status messages

You can at any time read the operating parameters of the keyboard by simply adding $80 to the command byte with which you would to set the operating mode (whose parameters you want to know). You then get a status package back (header=$F6), whose format corresponds exactly to those which would be necessary for setting the operating mode.

An example makes it clearer: you want to know how the mouse is scaled. So you send as the command the value $8C (since $0C sets the scaling). You get the following back:

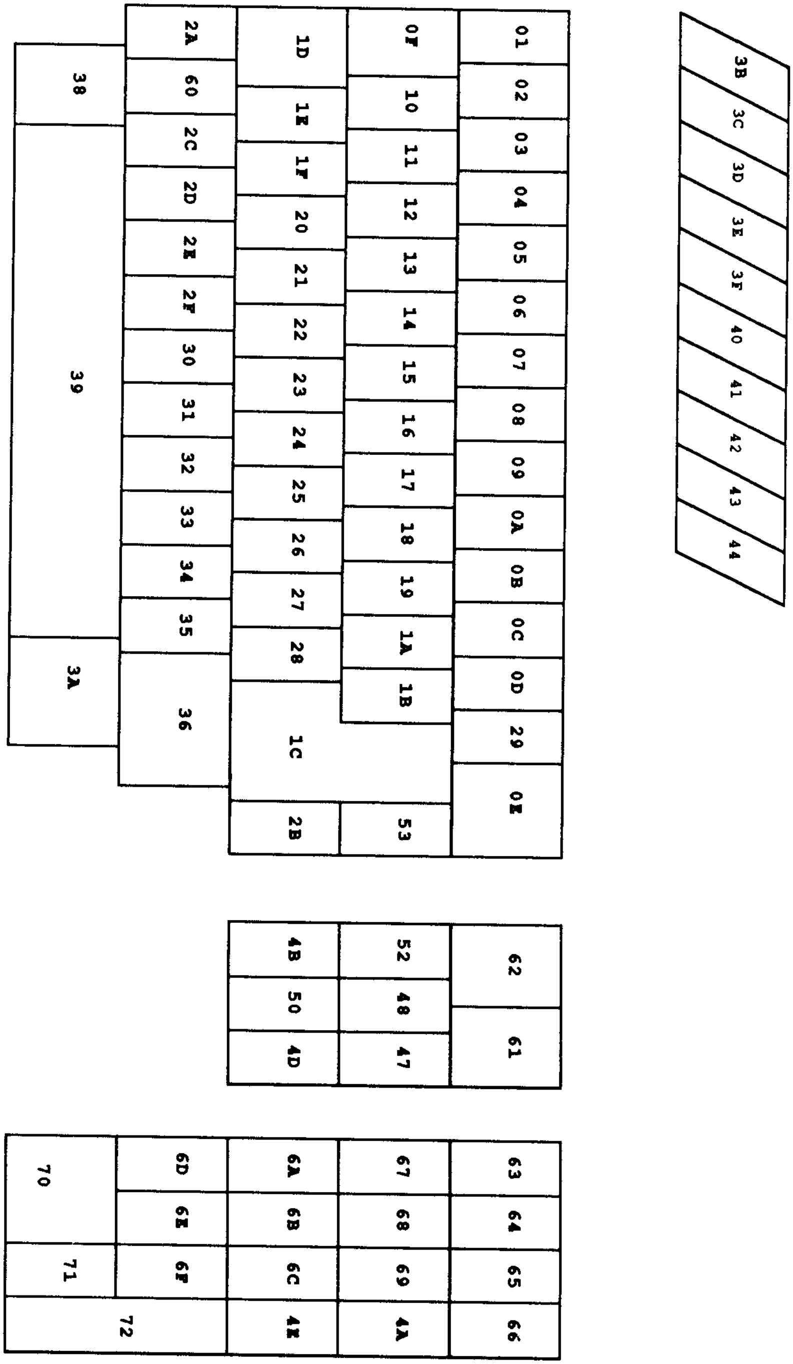
```
1 byte Status header =$F6
1 byte X-scaling
1 byte Y-scaling
```

This is the same format which would be necessary for the command $0C. For commands which do not require parameters, you get the evoked command back as such. For example, say you want to know what operating mode the joystick is in ($14 or $15). You send the value $94 (or $95, it makes no difference). As status package you receive, in addition to the header, either $14 or $15 depending on the operating mode of the joystick handler.

Allowed status checks are: $87, $88, $89, $8A, $8B, $8C, $8F, $90, $92, $94, $99, and $9A.

In conclusion we have a tip for those for whom the functions of the keyboard are too meager and who want to give it more "intelligence". The processor 6301 is also available in "piggy-back" version, the 63P01 (Hitachi). This model does not have ROM built in, but has a socket on the top for an EPROM of type 2732 or 2764 (8K!). You can then realize your own ideas and, for example, use the two joystick connections as universal 4-bit I/O ports, for which you can also extend the command set in order to access the new functions from the XBIOS as well.

Figure 2.1.2-1 ATARI ST Key Assignments



2.2 The Video Connection

Without this, nothing would be displayed. You would be typing blind. You'll notice the many pins on the connection. Naturally more lines are required for hooking up an RGB monitor than for a monochrome screen, but seven would be enough. There is also something special about the remaining lines. In Figure 2.2-1 you find a block diagram in which you can see how the video connection is tied to the system. The numbering of the pins is given on the figure on the next page, as you can see, when you look at the connector from the outside. Here is the pin layout:

1 AUDIO OUT. This connection comes from the amplifier connected to the output of the sound chip. A high-impedance earphone can be attached here if you do not use the original monitor.

2 COMPOSITE VIDEO is the connection from 9-12. This is not available on the early 520ST or 1040 ST.

3 GPO, General Purpose Output. This connection is available for your use. The line has TTL levels and comes from I/O port A bit 6 of the sound chip.

4 MONOCHROME DETECT. If this line, which leads to the I7 input of the MFP 68901, is low, the computer enters the high-resolution monochrome mode. If the state of the line changes during operation, a cold start is generated.

5 AUDIO IN leads to the input of the amplifier described in 1 and is there mixed with the output of the sound chip.

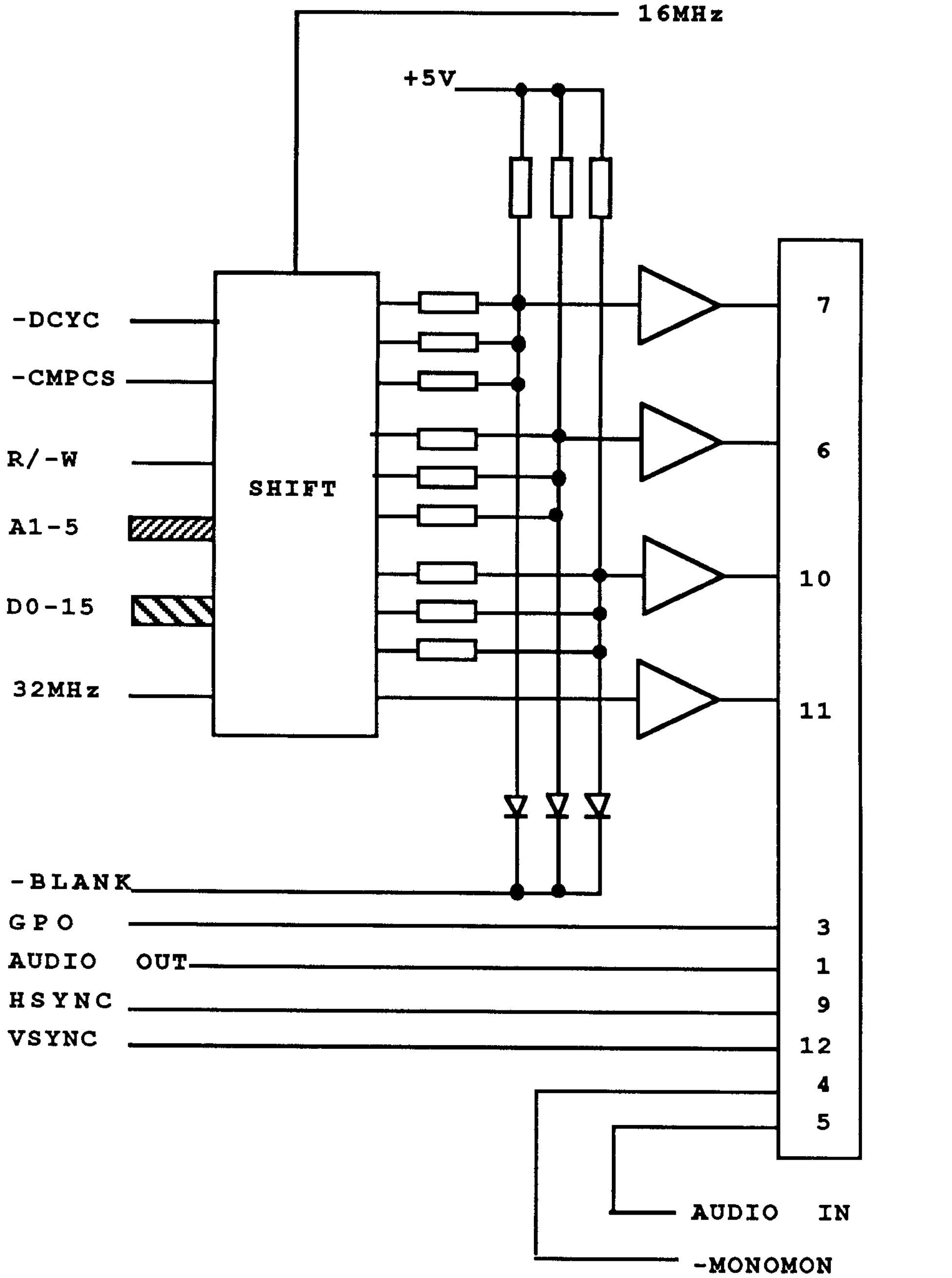
6 GREEN is the analog green output of the video shifter.

7 RED. Red output.

8 +12 control voltage for color televisions with video connectors. Atari 520ST = GROUND.

9 HORIZONTAL SYNC is responsible for the horizontal beam return of the monitor.

Figure 2.2-1 Diagram of Video Interface



10 BLUE is the analog blue output of the video shifter.

11 MONOCHROME provides a monochrome monitor with the intensity signal.

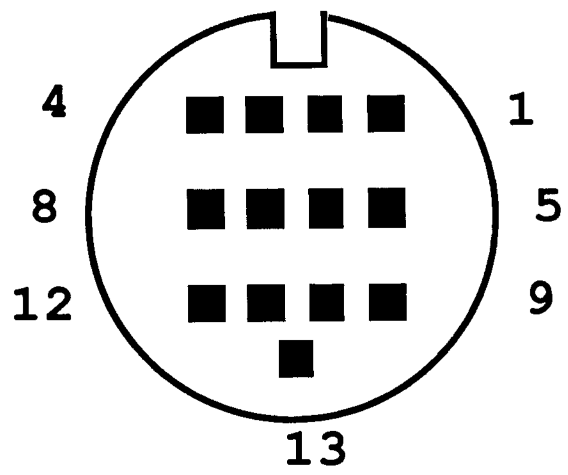
12 VERTICAL SYNC takes care of the beam return at the end of the screen.

13 GROUND.

A tip for the hardware hobbyist:

A plug to fit this connector is not available. If you want to make a plug for connecting other monitors, simply use a piece of perf board in which you have soldered pins, since the pins are fortunately organized in a 1/10" array. Pin 13 is out of order, but it is not needed since pin 8 is also available for ground.

Figure 2.2-2 Monitor Connector



2.3 The Centronics Interface

A standard Centronics parallel printer can be connected to this interface, provided that you have the proper cable. As you can see in Figure 2.3-2, the connection to the system is somewhat unusual. The data lines and the strobe of the universal port of the sound chip are used. So you find these too on the picture, in which the other lines, which will not be described in the section, will not disturb you. They belong to the disk drive and RS-232 interface and are handled there.

Here is the pin description:

1 -STROBE indicates the validity of the byte on the data lines to the connected device by a low pulse.

2-9 DATA

11 BUSY is always placed high by the printer when it is not able to receive additional data. This can have various causes. Usually the buffer is full or the device is off line.

18-25 GROUND.

All other pins are unused.

A tip for making a cable. Get flat-cable solderless connectors. You need a type D25-subminiature, a Cinch 36-pin (3M,AMP) and the appropriate length of 25-conductor flat ribbon cable. You squeeze the connectors on the cable so that pins 1 match up on both sides (they are connected together). The other connections then match automatically. Note that there will naturally be some pins free on the printer side.

Figure 2.3-1 Printer Port Pins

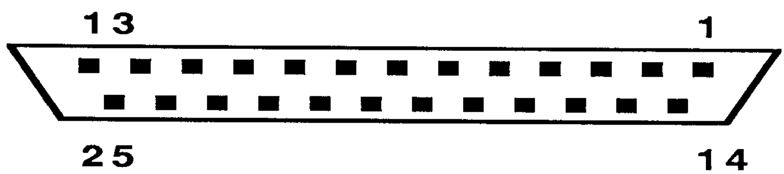
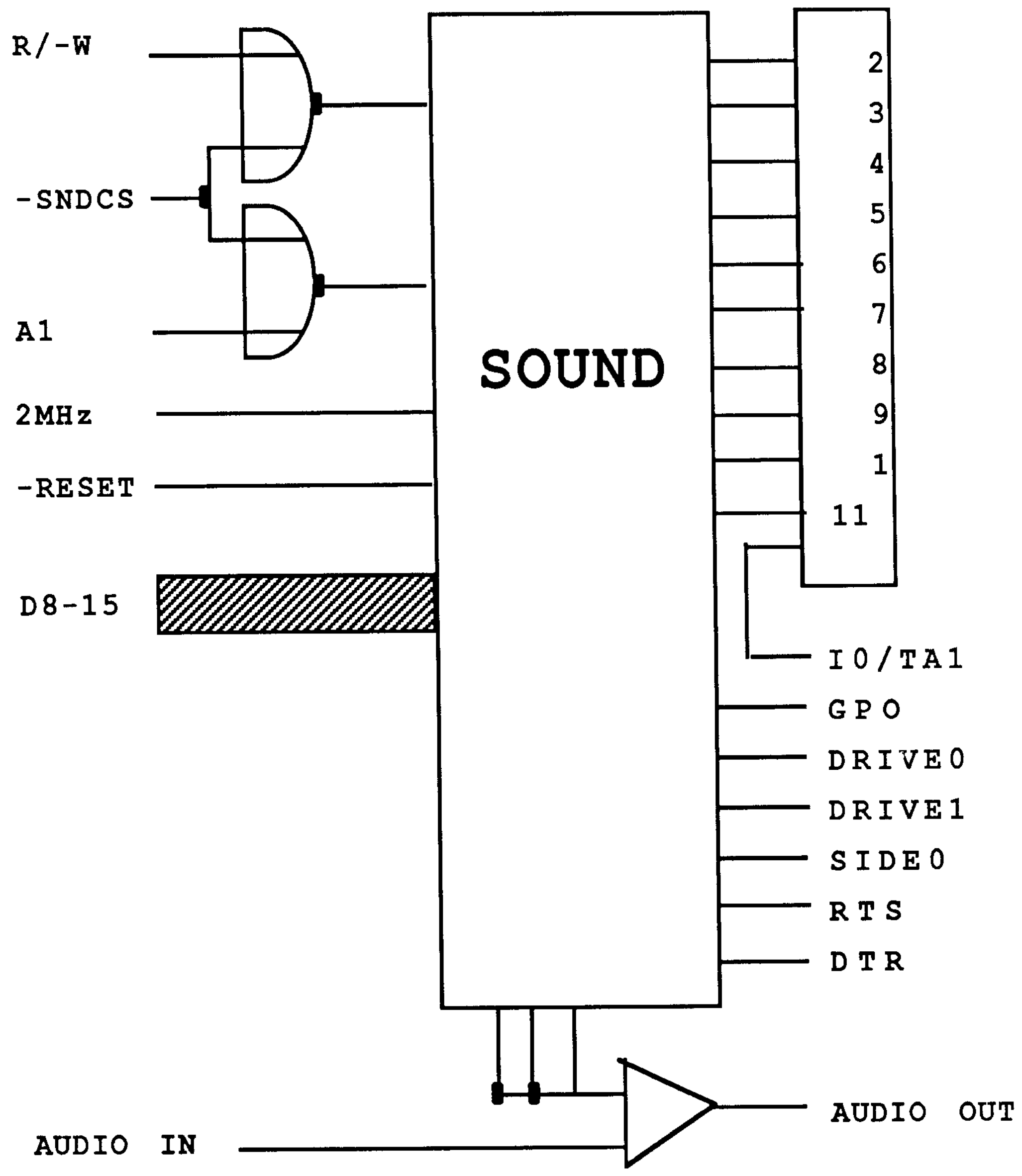


Figure 2.3-2 Centronics Connection



2.4 The RS-232 Interface

This interface usually serves for communication with other computers and modems. You can also connect a printer here. Note the description of pin 5!

Figure 2.4-1 shows the connection to the system. Normally you don't have to do any special programming to use this interface. It is taken care of by the operating system. Here the control of the interface is not controlled by a special IC (UART) as is usually the case, but the lines are serviced more or less "by hand." The shift register in the MFP is used for this purpose. The handshake lines however come from a wide variety of sources. Note this in the following pin description:

1 CHASSIS GROUND (shield)
This is seldom used.

2 TxD
Send data

3 RxD
Receive data

4 RTS
Ready to send comes from I/O port A bit 3 of the sound chip and is always high when the computer is ready to receive a byte. On the Atari, this signal is first placed low after receiving a byte and is kept low until the byte has been processed.

5 CTS
Clear to send of a connected device is read at interrupt input I2 of the MFP. At the present time this signal is handled improperly by the operating system. Therefore it is possible to connect only devices which "rattle" the line after every received byte (like the 520ST with RTS). The signal goes to input I2 of the MFP, but unfortunately is tested only for the signal edge. You will not have any luck connecting a printer because they usually hold the CTS signal high as long as the buffer is not full. There is no signal edge after each byte, which means that only the first byte of a text is transmitted, and then nothing.

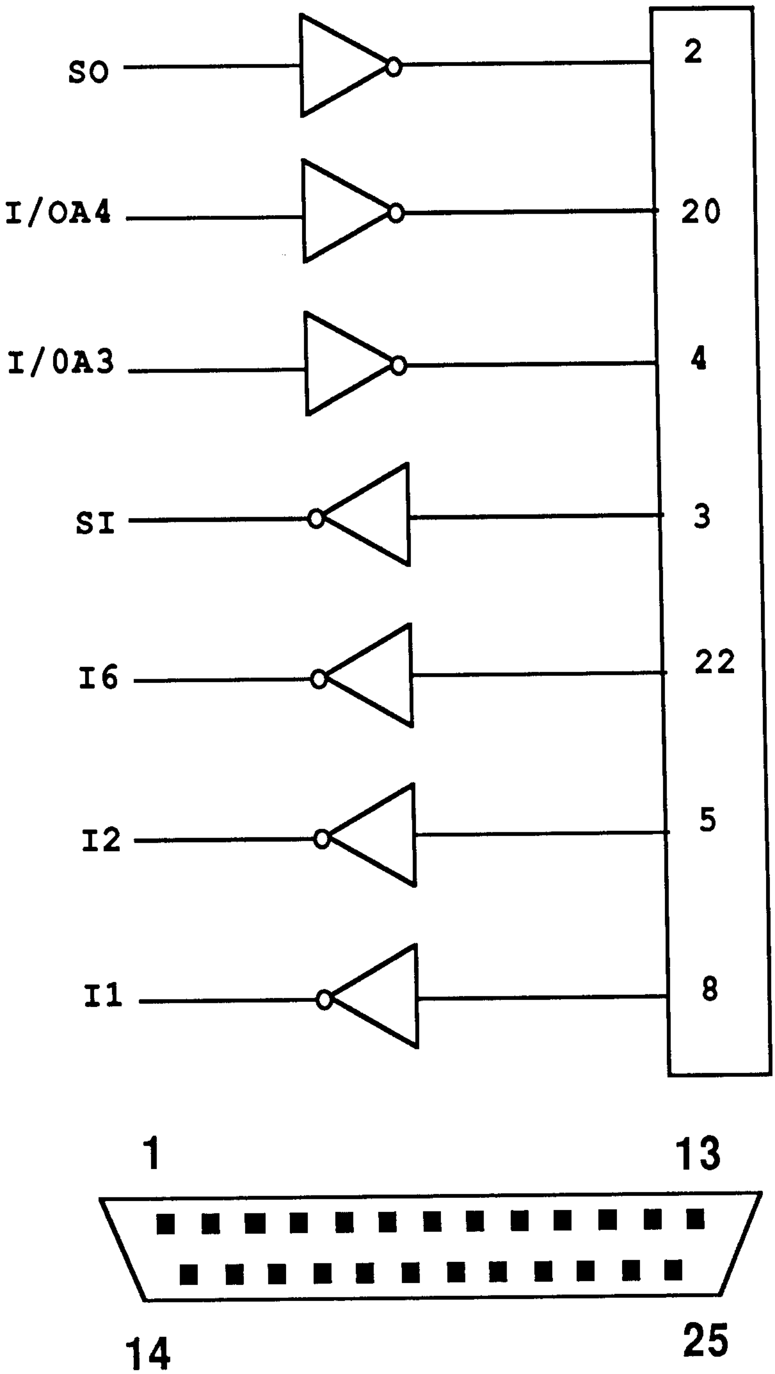
7 GND
Signal ground.

8 DCD
Carrier signal detected. This line, which goes to interrupt input I1 of the MFP, is normally serviced by a modem, which tells the computer that connection has been made with the other party.

20 DTR
Device ready. This line signals to a device that the computer is turned on and the interface will be serviced as required. It comes from I/O port A bit 4 of the sound chip.

22 RI
Ring indicator is a rather important interrupt on I6 of the MFP and is used by a modem to tell the computer that another party wishes connection, that is, someone called.

Figure 2.4-1 RS-232 Connection



2.5 The MIDI Connections

The term MIDI is probably unknown to many of you. It is an abbreviation and stands for Musical Instrument Digital Interface, an interface for musical instruments.

It is certainly clear that we can't simply hook up a flute to this port. So first a little history. Music professionals (more precisely: keyboardists, musicians who play the synthesizer) demanded agreement between the various manufacturers to interface computers to musical instruments. They found it absurd to connect complicated set-ups with masses of wire. The idea was to service several synthesizers from one keyboard.

The tone created was basically analog (and still is, to a degree), so that the manufacturers agreed that a control voltage difference of 1V corresponded to a difference in tone of 1 octave. This way one could play several devices under "remote control," but not service them.

This changed substantially when the change was made to digital tone creation. Here one didn't have to turn a bunch of knobs, there were buttons to press, whereby the basis for digital control was created.

Some manufacturers got together and designed a digital interface, the basic commands of which would be the same throughout, but which would still support the additional features of a given device.

The device is based on the teletype, the current-loop principle, which is not very susceptible to noise, but significantly faster. The transfer rate is 31250 baud (bits per second). The data format is set at one start bit, eight data bits, and one stop bit.

An IC can therefore be used for control which would otherwise be used for RS-232 purposes. You see the connection to the system in figure 2.5-1.

Logically, MIDI is multi-channel system, meaning that 16 devices can be serviced by one master, or a device with 16 voices. These devices are all connected to the same line (bus principle). To identify which device or which voice is intended, each data packet is preceded by the channel number. The device which recognizes this number as its own then executes the desired action.

You may wonder what such an interface is doing in a computer. A computer can provide an entire arsenal of synthesizers with settings or complete melodies (sequencer) because of its high speed and memory capacity. It can also be used to record and store input from a synthesizer keyboard.

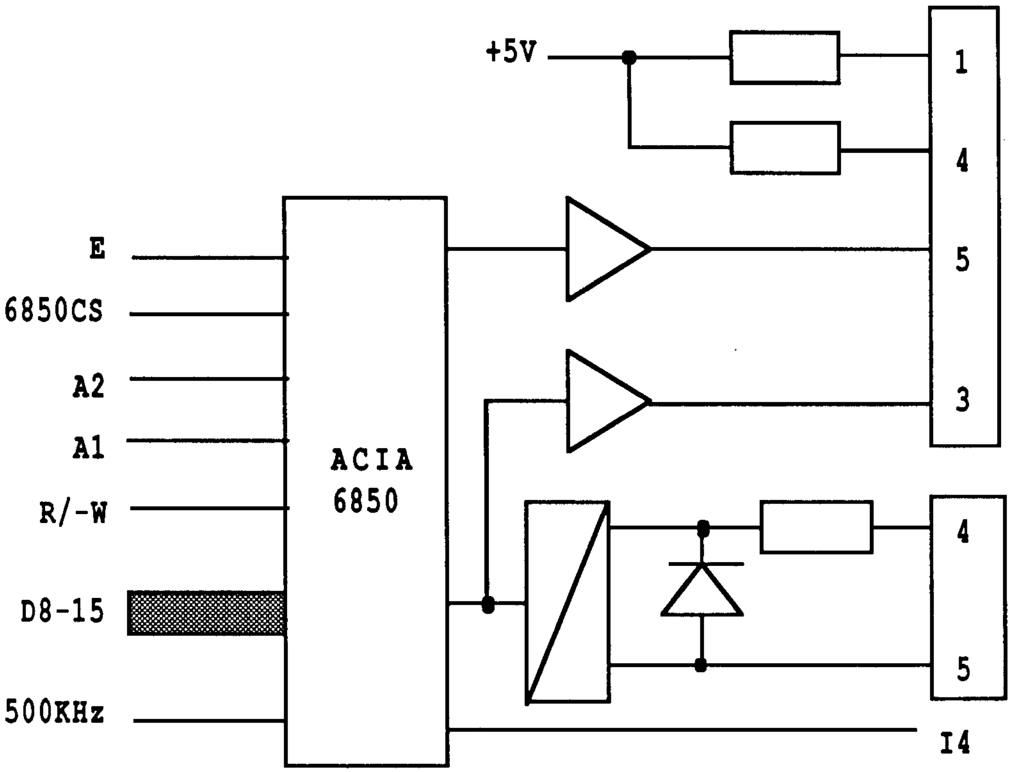
For this purpose the ST has the interfaces MIDI-IN and MIDI-OUT. The interfaces are even supported by the XBIOS so you don't have to worry about their actual operation.

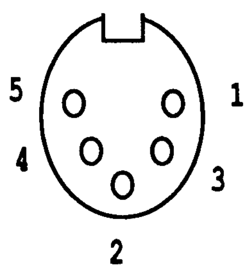
The current loop travels on pins 4 and 5, out through pin 4 (+) of MIDI-OUT and in at 5, when a device is connected.

For MIDI-IN the situation is reversed because the current flows in through pin 4 and back out through pin 5. It goes though something called an optocoupler which electrically isolates the computer from the sender.

The received data are looped back to MIDI-OUT (pins 1 and 3), which implements the MIDI-THRU function, although not entirely according to the standard.

Figure 2.5-1 MIDI System Connection





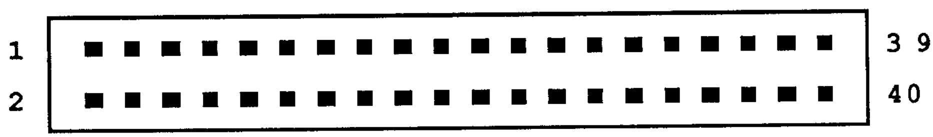
2.6 The Cartridge Slot

The cartridge slot can be used *exclusively* for inserting ROM cartridges. Up to 128K in the address space $FA0000 to $FBFFFF can be addressed. The reason we stressed the exclusivity of the read access is the following. We thought it would be practical to outfit a cartridge with RAM and then load programs into it after the system start which would still remain after a reset. In order to try this we brought the R/-W signal to the outside. The experience taught us, however, that a write access to these addresses creates a bus error. The GLUE takes care of this. As you see, nothing is left to chance in the Atari.

Figure 2.6-1 The Cartridge Slot

1 =	+5VDC	21 =	Address 8
2 =	+5VDC	22 =	Address 14
3 =	Data 14	23 =	Address 7
4 =	Data 15	24 =	Address 9
5 =	Data 12	25 =	Address 6
6 =	Data 13	26 =	Address 10
7 =	Data 10	27 =	Address 5
8 =	Data 11	28 =	Address 12
9 =	Data 8	29 =	Address 11
10 =	Data 9	30 =	Address 4
11 =	Data 6	31 =	ROM Select 3
12 =	Data 7	32 =	Address 3
13 =	Data 4	33 =	ROM Select 4
14 =	Data 5	34 =	Address 2
15 =	Data 2	35 =	Upper Data Strobe
16 =	Data 3	36 =	Address 1
17 =	Data 0	37 =	Lower Data Strobe
18 =	Data 1	38 =	GND
19 =	Address 13	39 =	GND
20 =	Address 15	40 =	GND

Position:



2.6.1 ROM Cartridges

We want to spend this section telling you how a program is put into ROM, as well as how the operating system recognizes and loads such a program.

These cartridges are technically feasible, since many manufacturers are now making ROM cartridge boards and programming devices for the ST computers.

The most important aspect is the first longword in ROM, which must contain an index number, or "magic number". This is read when the system start occurs—it checks to see whether there is a program cartridge or a diagnostic cartridge plugged into the cartridge port. The former must contain the index number $ABCDEF42, the latter the index number $FA52255F.

We wouldn't want to go any farther with the diagnostic cartridge. It should be enough that the operating system jumps to immediately test the address $FA0004 without initializing GEMDOS. You won't get any system processes anyway from this cartridge.

The program cartridges are what interest us. We can call up several programs from a ROM module of this type. Every program must have an introductory section, or application header, to be started by the operating system. The first must begin right after the magic number (from $FA0004), and must be made up of the following:

1 longword:
Address of the next header, when multiple programs reside in one cartridge. The header of the last (or only) program must contain $00000000.

1 longword:
Initialization code. This is where GEMDOS gets information, first about the handling of the program. In particular, this longword is made up of an address which points to the initialization routine (when needed). The most significant byte in this longword states at which point in time this routine should jump.

This is arranged as follows:

BIT
- 0 The routine will be executed before the interrupt vectors, video RAM, etc., is installed.
- 1 The routine will be executed before GEMDOS is initialized.
- 3 The routine will be executed before GEMDOS is loaded. NOTE: This function is not accessible to computers which have GEMDOS in ROM!
- 5 Character which indicates that the program should be handled as an accessory.
- 6 Character which identifies the program as a .TOS type, and not requiring the GEM system.
- 7 Character which identifies the program as a .TTP type, and requiring starting parameters.

1 longword:
Starting address of the program, i.e. where it would start if you double-clicked it.

1 word:
Time in DOS format; has no meaning during runtime.

1 word:
Date in DOS format, see the previous entry.

1 longword:
Program length in bytes; has no meaning during runtime.

String:
Program name in explanatory text. The program name is inserted according to normal conventions, i.e., up to 8 characters, a period (.), and three characters after the period. NOTE: The string absolutely must be concluded by $00.

So, that's it. As for the rest: We've neglected to give you any information on clicking. Some program cartridges have their own icons, similar to a disk drive icon. Click this icon. It will show the programs contained in the cartridge; you may then start the desired program.

2.7 The Floppy Disk Interface

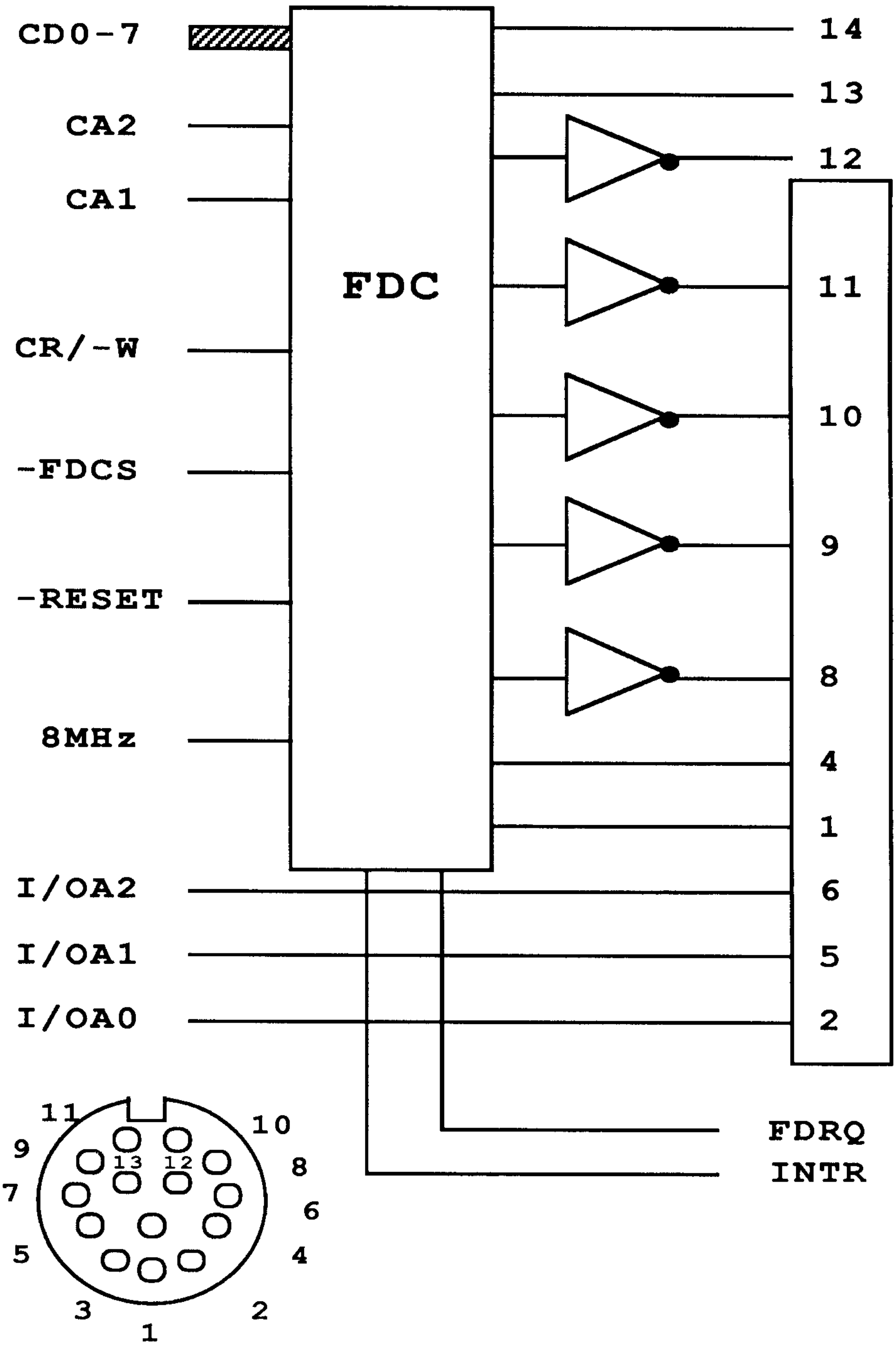
The interface for floppy disk drives is conspicuous because of the unusual connector, a 14-pin DIN connector. All of the signals required for the operation of two disk drives are available on it.

You know most of the signals from the description of the disk controller 1772, since nine of the available connections are connected to the controller either directly or through a buffer. Only the drive select 1 and drive select 2 signals and the side 0 select are not derived from the disk controller. These signals come from port A of the sound chip.

Pinout of the disk connector:

```
1 READ DATA              8 MOTOR ON
2 SIDE 0 SELECT          9 DIRECTION IN
3 GND                   10 STEP
4 INDEX                 11 WRITE DATA
5 DRIVE 0 SELECT        12 WRITE GATE
6 DRIVE 1 SELECT        13 TRACK 00
7 GND                   14 WRITE PROTECT
```

Figure 2.7-1 Disk Connection



2.8 The DMA Interface

This 19-pin jack can handle up to 8 DMA-compatible devices. These include hard disks, networks, and even coprocessors. The communications between the external devices and the ST run at a speed of up to 1 million bytes per second.

1-8 D0-D7
Bidirectional data lines

9 CS
Chip Select, low-active. This line is activeated from the computer when either commands are sent to the device, or status bytes are read from there. If DMA transfer is in process, the signal is in a wait state.

10 IRQ
Interrupt Request, low=active. This signal is produced by the device, and tells the computer that an action is done (e.g., DMA transfer).

11 GND

12 RST
Reset, low=active.

13 GND

14 ACK
Acknowledge, low-active. This signal only has meaning during DMA transfer. This indicates the device to the computer's DMA controller, depending on the data direction, whether a byte is received from the device or whether a legal data byte lies on the bus.

15 GND

16 A1
Address 1. This signal tells the device's DMA controller whether the device address is set on bus with all commands (A1=low) or whether parameter bytes are handled (usually 5 parameter bytes; A1=high).

17 GND

18 R/W
Read/Write. This line also controls the controller, and is valid only when initializing. Write(=low): Command bytes snet; Read (=high): Waiting for a status byte.

19 DRQ
Data Request, low=active. This signal is produced from the device only during DMA transfer, depending upon data direction, when it can receive a byte from the controller; or otherwise, set a byte on the bus.

There are two different methods of transfer. One is a computer controlled data transfer using the A1, CS and R/W lines. The other transfer of data, controlled from the device itself (the DMA transfer), runs without the computer with the help of the DRQ and ACK lines.

A connection can be seen between the chip description of the DMA controller, and the reset routine in the operating system, which checks for all eight possible DMA devices.

Figure 2.8-1 DMA Port

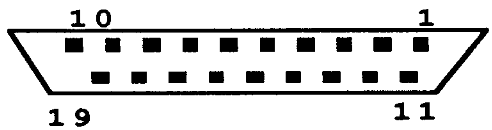
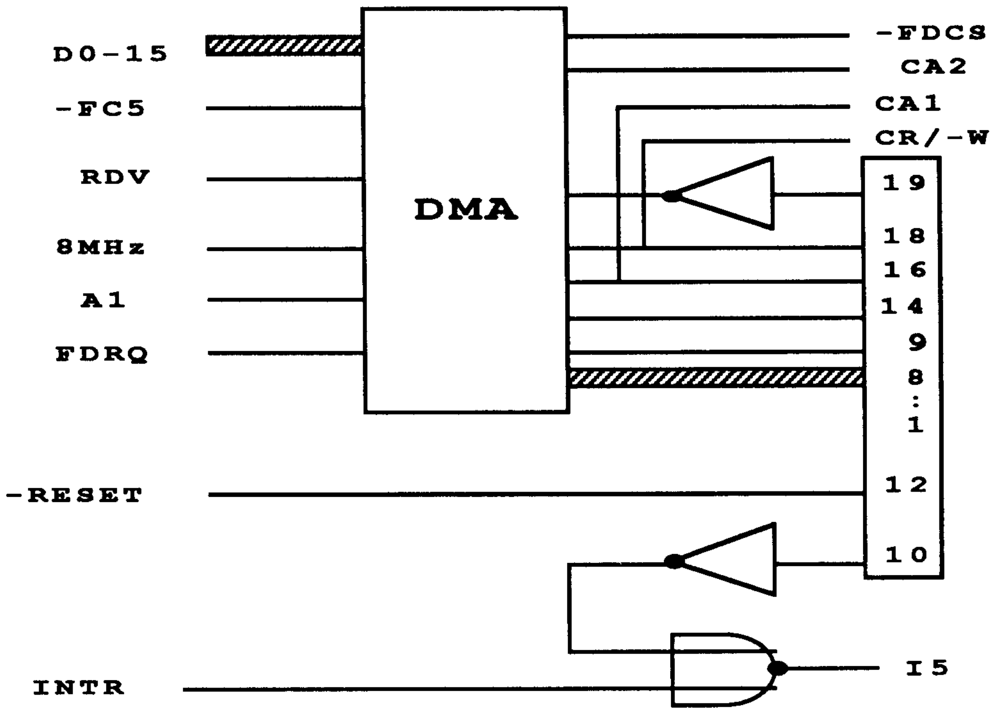


Figure 2.8-2 DMA Connections



Chapter 3

The ST Operating System

The ST Operating System

GEMDOS--what is it? Is it in the ST? The operating system is supposed to be TOS, though. Or is it CP/M 68K? Or what?

These questions can be answered with few words. The operating system in the ST is named TOS--Tramiel Operating System--after the head of Atari. This TOS, in contrast to earlier information has nothing to do with CP/M 68K from Digital Research. At the start of development of the ST, CP/M 68K was implemented on it, but this was later changed because CP/M 68K is not exactly a model of speed and efficiency. A 68000 running at 8MHz and provided with DMA would be slowed considerably by the operating system.

At the beginning of 1985, Digital Research began developing a new operating system for 68000 computers, which would include a user-level interface. This operating system was named GEMDOS. It is exactly this GEMDOS which makes up the hardware-independent part of TOS. Like CP/M, TOS consists of a hardware-dependent and a hardware-independent part. The hardware-dependent part is the BIOS and the XBIOS, while the hardware-independent part is called GEMDOS. A large number of functions are built into GEMDOS, through which the programmer can control the actual input/output functions of the computer. Functions for keyboard input, text output on the screen or printer, and the operation of the various other interfaces are all present. Another quite important group contains the functions for file handling and for logical file and disk management.

3.1 The GEMDOS

When you look at the functions available under GEMDOS, you will eventually come to the conclusion that the whole thing is not really new. All the functions in GEMDOS are very similar to the functions of the MS-DOS operating system. Even the functions numbers used correspond to those of MS-DOS. But not all MS-DOS functions are implemented in GEMDOS. Especially in the area of file management, only the UNIX compatible functions are implemented in GEMDOS. The "old" block-oriented functions which are included in MS-DOS to maintain compatibility with CP/M are missing from GEMDOS. Also, special functions relating to the hardware of MS-DOS computers (8088 processor) are missing.

Another essential difference between MS-DOS and GEMDOS is that for GEMDOS calls as well as for the BIOS and XBIOS, the function number, the number of the desired GEMDOS routine, and the required parameters are placed on the stack and are not passed in the registers. The 68000 is particularly suited to this type of parameters passing. GEMDOS is called with `trap #1` and the function is executed according to the contents of the parameter list. After the call, the programmer must put the stack back in order himself, by clearing the parameters from memory.

The basic call of GEMDOS functions differs from the BIOS and XBIOS calls only in the trap number.

In regard to all GEMDOS calls, it must be noted that registers D0 and A0 are changed in all cases. If a value is returned, it is returned in D0, or D0 may contain an error number, and after the call A0 (usually) points to the stack address of the function number. Any parameters required in D0 or A0 must be placed there before GEMDOS is called.

The remainder of this section describes the individual GEMDOS functions.

$00 TERM

C: void Pterm0()

Calling GEMDOS with function number 0 ends the running program and returns to the program from which it was started. For applications (programs started from the desktop), control is returned to the desktop. If the program was called from a different program, control is passed back to the calling program. This point is important for chaining program segments.

```
clr.w  -(sp)
trap
```

$01 CONIN

C: long Cconin()

CONIN gets a single character from the keyboard. The routine waits until a character is available. The character read from the keyboard is returned in the D0 register. The ASCII code of the pressed key is returned in the low byte of the low word, while the low byte of the high word of the register contains the scan code from the keyboard. This is important for reading keys which have no ASCII code, such as the 10 function keys or the editing keys. These keys return the ASCII value zero when pressed.

The scan code can be used to determine if the keypad or the main keys were pressed. These keys have identical ASCII codes, but different scan codes.

In addition, Shift status can be determined from the upper eight bits (bits 24 to 31) by calling Cconin. In this case, bits 24-31 correspond to bits 0 to 7 in BIOS function 11 ("kbshift"). The information can only be sent on a Cconin call when bit 3 of the memory location "conterm" (address $484) is set. If this bit is unset, then the shift bits after Cconin are deleted.

Cconin does not recognize <Control><C>.

```
move.w #1,-(sp)      Function number on the stack
trap   #1            Call GEMDOS
addq.l #2,sp         Correct stack
```

$02 CONOUT

```
C: void Cconout(c)
   int c;
```

CONOUT, also known as Cconout, represents the simplest and most primitive character output of GEMDOS. With this function only one character is printed on the screen. The character to be displayed is placed on the stack as the first word. The ASCII value of the character to be printed must be in the low byte of the word and the high byte should be zero.

The character printed by CONOUT is sent to device number 2, the normal console output. Control characters and escape sequences are interpreted normally.

```
move.w #65,-(sp)     Output an A
move.w #2,-(sp)      CONOUT
trap   #1            Call GEMDOS
addq.l #4,sp         Correct stack
```

$03 AUXILIARY INPUT

```
C: int Cauxin()
```

The RS-232 interface of the ST goes under the designation "auxiliary port". A character can be read from the interface with the Cauxin function. The function returns when a character has been completely received. The character is returned in the lower eight bits of register D0.

```
move.w #3,-(sp)      Cauxin
trap   #1            Call GEMDOS, output character
addq.l #2,sp         Correct stack
.                    Character in D0
```

$04 AUXILIARY OUTPUT

```
C: void Cauxout(c)
   int c;
```

A character can be transmitted over the serial interface, similar to the input of characters. With this function the programmer should clear the upper eight bits of the word and pass the character to be sent in the lower eight bits.

```
move.w #$41,-(sp)     An A should be output
move.w #4,-(sp)       Cauxout
trap   #1             Call GEMDOS, output character
addq.l #4,sp          Correct stack
```

$05 PRINTER OUTPUT

```
C: void Cprnout(c)
   int c;
```

PRINTER OUTPUT is the simplest method of operating a printer connected to the Centronics interface. One character is printed with each call.

An important part of PRINTER OUTPUT is the return value in D0. If the character was sent to the printer, the value -1 ($FFFFFFFF) is returned in D0. If, after 30 seconds, the printer was unable to accept the character (not turned on, OFF LINE, no paper, etc.), GEMDOS returns a time out to the program. D0 then contains a zero.

```
move.w #65,-(sp)      Output an A
move.w #5,-(sp)       Function number
trap   #1             Call GEMDOS, output character
addq.l #4,sp          Correct stack
tst.w  D0             Affect flags
beq     printererror
```

$06 RAWCONIO

```
C: long Crawio(c)
   int c;
```

RAWCONIO is a somewhat unusual mixture of keyboard input and screen output; it also receives a parameter on the stack.

The keyboard is tested with a function value of $FF. If a character is present, the ASCII code and scan code are passed to D0 as described for CONIN. If no key value is present, the value zero is passed as both the ASCII code and the scan code in D0. The call to RAWCONIO with parameter $FF is comparable to the BASIC INKEY$ function.

If a value other than $FF is passed to the function, the value is interpreted as a character to be printed and it is output at the current cursor position. This output also interprets the control characters and escape sequences properly.

```
START:

move.w #$ff,-(sp)     Function value test keyboard
move.w #6,-(sp)       Function number
trap   #1             Call GEMDOS, test keyboard
addq.l #4,sp          Correct stack
tst.w  D0             Character arrived?
beq    START          Not yet
cmp.b  #3,D0          ^C selected as the end marker
beq    END
move   D0,-(sp)       Character for output on the stack
move   #6,-(sp)       Function number
trap   #1             Call GEMDOS, test keyboard
addq.l #4,sp          Correct stack
bra    START          Get new character
```

$07 DIRECT CONIN WITHOUT ECHO

```
C: long Crawcin()
```

The function $07 differs from $01 only in that the character received from the keyboard is not displayed on the screen. It waits for a key just as does CONIN.

```
move.w #8,-(sp)     Cauxin
trap   #1           Call GEMDOS, output character
addq.l #2,sp        Adjust stack
.                   Character in D0
```

$08 CONIN WITHOUT ECHO

```
C: long Cnecin()
```

Both function $08 and function $07 have exactly the same effect. The reason for this seemingly nonsensical behavior lies in the abovementioned compatibility to MS-DOS. Under MS-DOS these two functions are different in that with $08, certain keys not present on the ATARI are evaluated correctly, while this evaluation does not take place with function $07.

```
move.w #8,-(sp)     Cauxin
trap   #1           Call GEMDOS, output character
addq.l #2,sp        Adjust stack
.                   Character in D0
```

$09 PRINT LINE

```
C: void Cconws(c)
   int c;
```

You are already familiar with functions that output individual characters on the screen (see CONOUT and RAWCONIO). PRINT LINE offers you an easy way to output text. An entire string can be printed at the current cursor position with this function. To do this, the address of the string is placed on the stack as a parameter. The string itself is concluded with a zero byte. Escape sequences and control characters can also be displayed with this function.

After the call, D0 contains the number of characters which were printed. The length of the string is not limited.

```
move.l   #text,-(sp)      Address of the string on the stack
move     #$09,-(sp)       Function number PRT LINE
trap     #1               Call GEMDOS
addq.l   #6,sp            Clear the stack
.
.
text     .dc.b 'This is the string to be printed',$0D,$0A,0
```

$0A READLINE

```
C; void Cconrs(buf)
   char *buf;
```

READLINE is a very easy-to-use function for reading characters from the keyboard. In contrast to the "simpler" character-oriented input functions, an entire input line can be taken from the keyboard with READLINE. The characters entered are displayed on the screen at the same time.

The address of an input buffer is passed to the function as the parameter. The value of the first byte of the input buffer determines the maximum length of the input line and must be initialized before the call. At the end of the routine, the second byte of the buffer contains the number of characters entered. The characters themselves start with the third byte.

The routine used by READLINE for keyboard input is quite different from the character-oriented console inputs. Escape sequences are not interpreted during the output. Only control characters like <Control><H> (backspace) and <Control><I> (TAB) are recognized and handled appropriately. The following control characters are possible:

```
^C  Ends input and program (!)
^H  Backspace one position
^I  TAB
^J  Linefeed, end input
^M  CR, end input
^R  Entered line is printed in new line
^U  Don't count line, start new line
^X  Clear line, cursor at start of line
```

A function like ^H (deleting a character entered) is useful, but for large programs you should write your own input routine because ^C is very

"dangerous." Unlike CP/M, the program will be ended even if the cursor is not at the very start of the input line.

If more characters are entered than were indicated in the first byte of the buffer at the initialization, the input is automatically terminated. If the input is terminated by ENTER, ^J, or ^M, the terminating character will not be put in the buffer.

After the input, D0 contains the number of characters entered, excluding ENTER, which can be found at buffer+1.

```
pea     buffer          Address of the input buffer
move    #$0A,-(sp)      Function number
trap    #1
addq.l #6,(sp)          Make room on stack
.
.
buffer dc.b 20          We want a maximum of 20 characters
       dc.b 0           Number of given characters
       ds.b 20          of the input buffer
```

$0B CONSTAT

```
C: int CConis()
```

All key presses are first stored in a buffer in the operating system. This buffer is 64 bytes in length. The key values stored there are taken from the buffer when a call to a GEMDOS output routine is made.

CONSTAT can be used to check if characters are stored in the keyboard buffer. After the call, D0 contains the value zero or $FFFF. A zero in D0 indicates that no characters are available.

```
testloop:
move    #$0B,-(sp)        Function number
trap    #1
addq.l #2,(sp)            Make room on stack
tst.w    D0              Character available?
beq      testloop       NO, then look again
```

$0E SETDRV

```
C: long Dsetdrv(drv)
   int drv;
```

The current drive can be determined with the function SETDRV. A 16-bit parameter containing the drive specification is passed to the routine. Drive A is addressed with the number 0 and drive B with the number 1.

After the call, D0 contains the number of the drive active before the call.

```
move    #$2,-(sp)      Drive C, e.g. RAMdisk
move    #$0E,-(sp)     Function number
trap    #1
addq.l  #4,(sp)        Make room on stack
.                      Previous current drive in D0
```

$10 CONOUT STAT

```
C: int Cconos()
```

CONOUT STAT returns the console status in D0. If the value $FFFF is returned, a character can be displayed on the screen. If the returned value is zero, no character output is possible on the screen at that time. Incidentally, all attempts failed at creating a not-ready status at the console. The only imaginable possibility for the not-ready status would be if the output of the individual bit pattern of a character was interrupted and the interrupt routine itself tried to output a character. This case could not, however, be created.

```
move    #$10,-(sp)     Function number
trap    #1
addq.l  #2,(sp)        Make room on stack
.                      Always $FFFF in D0
```

$11 PRTOUT STAT

```
C: int Cprnos()
```

This function returns the status, the condition of the Centronics interface. If no printer is connected (or turned off, or off line), D0 contains the value zero after the call to indicate "printer not available." If, however, the printer is ready to receive, D0 contains the value $FFFF.

```
move    #$11,-(sp)      How's the printer doing?
trap    #1
addq.l  #2,(sp)         Make room on the stack
tst     d0
beq      printererror   Go here if not ready
```

$12 AUXIN STAT

```
C: int Cauxis(c)
```

AUXIN STAT shows whether a character is available from the serial interface receiver ($FFFF) or not ($0000). The value is returned in D0.

```
waitloop:
move    #$12,-(sp)      We wait for a character
trap    #1              from the serial interface
addq.l  #2,(sp)         Make room on the stack
tst     d0              Is there a character there?
bne     waitloop        No, not yet
```

$13 AUXOUT STAT

```
C: int Cauxos()
```

AUXOUT STAT gives information about the state of the serial bus. A value of $FFFF indicates that the serial interface can send a character, while zero indicates that no characters can be sent at this time.

```
waitloop:
move    #$13,-(sp)      Wait for a character
trap    #1              from the serial interface
addq.l  #2,(sp)         Make room on the stack
tst     d0              Received one yet?
bne     waitloop        No, not yet
```

$19 CURRENT DISK

```
C: int Dgetdrv()
```

For many applications it is necessary to know which drive is currently active. The current drive can be determined by the function $19. After the call, D0 contains the number of the drive. The significance of the drive numbers is the same as for $0E, SET DRIVE (0=A, 1=B).

```
move    #$19,-(sp)      Which drive is active?
trap    #1              It will be sent over
                        the serial interface
addq.l  #2,(sp)         Make room on the stack
ADD     D0,'A'          There will now be a character in
                        D0 between 'A' and 'P'
```

$1A SET DISK TRANSFER ADDRESS

```
C: void Fsetdta(buf)
   char *buf;
```

The disk transfer address is the address of a 44-byte buffer required for various disk operations (especially directory operations). Along with the GEMDOS functions SEARCH FIRST and SEARCH NEXT are examples for using the DTA.

```
move.l #DTADDRESS,-(sp) Address of the 44-byte DTA buffer
move.w #$1a,-(sp)       Function number SET DTA
trap   #1               Set DTA
addq.l #6,sp            Clean up the stack
```

$20 SUPER

This function is especially interesting for programmers who want to access the peripherals or system variables available only in the supervisor mode while running a program in the user mode. After calling this function from user mode, the 68000 is placed in the supervisor mode. In contrast to the XBIOS routine for enabling the supervisor mode, additional GEMDOS, BIOS, and XBIOS calls can be made after a successful SUPER call.

Calling the SUPER function with a value of -1L ($FFFFFFFF) tells us the processor's current operating mode. If the result in D0 after the call is 0, the processor is in user mode. A value of $0001 signifies that the processor is in supervisor mode. Switching modes is not carried out yet.

A program in user mode can call the SUPER function with a zero on the stack. In this case, the supervisor mode will be turned on. The supervisor stack pointer points to the current value of the user stack, and the original value of the supervisor stack is in D0. This value must be stored in the program to later return to the user mode. If the change to user mode is not made before the end of the program, the odds of a system crash are good.

If a value other than zero is passed to the SUPER function the first time it is called, this value is interpreted as the desired value of the supervisor stack pointer. In this case as well, D0 contains the original value of the supervisor stack pointer, which the program should save.

As mentioned above, the user mode should be reenabled before the end of the program. This change of modes requires setting the address used by the supervisor stack pointer back to its original value.

The SUPER function differs from all other GEMDOS functions in one very important respect. Under certain circumstances, this call can also change the contents of A1 and D1. If you store important values in these registers, you must save the values somewhere before calling the SUPER function.

```
                            The 68000 is in the user mode
clr.l   -(sp)               User stack becomes supervisor stack
move.w #$20,-(sp)           Call SUPER
trap    #1                  Supervisor mode is active after TRAP
add.l   $6,sp               D0 = old supervisor stack
move.l d0,_SAVE_SSP         Save value
.
.   Here processing can be done in the supervisor mode
```

```
.
move.l _SAVE_SSP,-(sp)   Old supervisor stack pointer
move.w #$20,-(sp)        Call SUPER
trap   #1                Now we are back in the user mode
add.l  #6,sp
```

$2A GET DATE

C: int Tgetdate()

You have no doubt experimented with the status field at one time or another. Among other functions, the status field contains a clock with time and date. It can be useful for some applications to have that data available. The date can be easily determined by GET DATE. This call requires no parameters and puts the date in the low word of register D0. It is thoroughly encoded, though, so the result in D0 must be prepared to get the correct date.

The day in the range 1 to 31 is coded in the lower five bits. Bits 5 to 8 contain the month in the range 1 to 12, and the year is contained in bits 9 to 15. The range of these "year bits" goes from 0 to 119. The value of these bits must be added to the value 1980 to get the actual year. The date 12/12/1992, for example, would be %0001100.1100.01100 in binary, or $198C in D0. The lengths of the three fields are marked with periods.

```
move    #$2a,-(sp)        We want to get some data
trap    #1
addq.l  #2,(sp)
move    d0,d1           Store result in D1 for now
and     #%11111,D0      Mask the day bits and
move    d0,DAY          store them
LSR     #5,d1           Shift the 5 day bits
move    d1,d0
and     #%1111,d0       and mask the month bits
move    D0,MONTH        Store the month number
LSR     #4,d1           Shift the month bits
move    d1,YEAR         Year is in D1
.
DAY     ds.w    1
MONTH   ds.w    1
YEAR    ds.w    1
```

$2B SET DATE

```
C: int Tsetdate(date)
   int date;
```

The clock time and date can also be set from application programs. This is particularly interesting for programs which use the date and/or clock time. An example of this would be invoice processing in which the current date is inserted in the invoice. Such programs can then ask the user to enter the date. This avoids the problems that occur if the user forgets to set the date and clock time on the status field beforehand.

The date must be passed to the function SET DATE in the same format as it is received from GET DATE, bits 0-4 = day, bits 5-8 = month, bits 9-15 = year-1980.

```
move.w #%101101011001,-(sp)   Set date to 10/25/1985
move.w #$2b,-(sp)             Function number of SET DATE
trap   #1                     Set date
addq.l #4,sp                  Repair stack
```

$2C GET TIME

```
C: int Tgettime()
```

The function GET TIME returns the current (read: set) time from the GEMDOS clock. Similar to the date, the clock time is coded in a special pattern in individual bits of the register D0 after the call. The seconds are represented in bits 0-4. But since only values from 0 to 31 can be represented in 5 bits, the internal clock runs in two second increments. In order to get the correct seconds-result the contents of these five bits must be multiplied by two. The number of minutes is contained in bits 5 to 10, while the remaining bits 11-15 give information about the hour in 24-hour format.

```
waitloop:

move    #$2c,-(sp)      Is it noon yet?
trap    #1              Get the time from GEMDOS
addq.l #2,sp
move    d0,d1           Store result in D1
```

```
and     #$1111,D0       Store seconds in steps
move    D0,SEC          of two
LSR     #4,D1           Shift 4 second bits
bne     waitloop        No, not yet
```

$2D SET TIME

```
C: int Tsettime(time)
   int time;
```

It is also possible to set the clock time under GEMDOS. The function SET TIME expects a 16-bit value (word) on the stack, in which the time is coded in the same form as that in which GET TIME returns the clock time.

When GEMDOS has the given time, D0 returns the value 0; otherwise the value returned is $FFFFFFFF. GEMDOS handles time much as it does the date. Time changes through GEMDOS cannot be conveyed through the XBIOS. Select either XBIOS or GEMDOS. If you cross the two, you will end up with some very unpleasant complications.

```
move.w #%1000101010111101,-(sp)     Clock time 17:21:58
move.w #$2D,-(sp)                   Function # of GET TIME
trap   #1                         Set date
addq.l #4,sp                      Repair stack
```

$2F GET DTA

```
C: long Fgetdta()
```

The function $2F is the counterpart of SET DTA ($1A). A call to GET DTA returns the current disk transfer buffer address in D0. A description of this buffer is found with the functions SEARCH FIRST and SEARCH NEXT.

```
move    #$2f,-(sp)      Function number Fgetdta
trap    #1              Get DTA
addq.l #2,sp
move.l d0,DTAPOINTER  and mark for later
.
```

$30 GET VERSION NUMBER

```
C: int Sversion()
```

Calling this function returns in D0 the version number of GEMDOS. In the version of GEMDOS currently in release, this question is always answered with $0D00, corresponding to version 13.00. Official Atari documentation claims that a value of $0100 should be returned for this version, though perhaps the value should indicate that the present GEMDOS version is the $D = diskette version.

```
move    #30,-(sp)       Look to see which
trap    #1              version we have
addq.l  #2,sp
cmp     #$1300,d0       The recognized version?
bne     not_tos         It can't be given
 .
```

$31 KEEP PROCESS

```
C: void Ptermres(keepcnt,retcode)
   long keepcnt;
   int retcode;
```

This function is comparable to the GEMDOS function TERM $00. The program is also ended after a call to this function. $31 does differ from $00 in several important points.

After processing `TRAP#1`, like TERM, control is passed back to the program which started the program just ended. In contrast to TERM, a termination condition can be communicated to the caller. While TERM returns the termination value zero (no error), zero or one may be selected as the termination value for $31. A value other than zero means that an error occurred during program processing.

Another essential point lies in the memory management of GEMDOS. When a program is started, the entire available memory space is made available to it. If the program is ended with TERM, the memory space is released and made available to GEMDOS. The entire area of memory released is also cleared, filled with zeros. The program actually physically disappears from the memory. With function $31, however, an area of memory can be

protected at the start address of the program. This memory area is not released when the program is ended and it is also not cleared. The program could be restarted without having to load it in again.

Practical applications for Ptermres() are spoolers, RAM disks and other utilities which are installed once and remain in memory for storage or processing. At the same time, such programs must be ended correctly after installation to allow other programs to be loaded and started.

KEEP PROCESS is called with two parameters. The example program shows the parameter passing. It is also important that memory additionally reserved for programs be Malloc not be freed up. If files are opened by Ptermres() at that time, these will be closed by GEMDOS.

```
move.w #0,-(sp)       Error code no error, else 1
move.l #$1000,-(sp)   Protect $1000 bytes at program start
move.w #$31,-(sp)     Function number, end program
trap   #1                ....now.
.                     This time, don't clear the stack!
```

$36 GET DISK FREE SPACE

```
C: void Dfree(buffer,drive)
   long *buffer
   int drive
```

It can be very important for disk-oriented programs to determine the amount of free space on the diskette, then warn the user to change disks. "Disk full" messages or even data loss can then be avoided.

Function $36, Dfree(), returns this information. The number of the desired disk drive and the address of a 16-byte buffer must be passed to the function. If the value 0 is passed as the drive number, the information is fetched from the active drive, a 1 takes the information from drive A, and a 2 from drive B.

The information passed in the buffer is divided into four longwords. The first longword contains the number of free allocation units. Each file, even if it is only eight bytes long, requires at least one such allocation unit.

The second longword gives information about the number of allocation units present on the disk, regardless of whether they are already used or are still free. For the "small" single-sided diskettes this value is $15C or 351, while the double-sided disks have $2C7 = 711 allocation units.

The third longword contains the size of a disk sector in bytes. For the Atari this is always 512 bytes ($200 bytes).

The last longword is the number of physical sectors belonging to an allocation unit. This is normally 2. Two sectors form one allocation unit.

The amount of free disk space can be easily calculated from this data.

```
move.w #0,-(sp)       Information from the active drive
pea    BUFFER         Address of the 16-byte buffer
move   #$36,-(sp)     Function number
trap   #1
addq.l #6,sp          Clean up stack
 .
 .
 .
BUFFER:
freal: .ds.l   1      Free allocation units
total: .ds.l   1      Total allocation units
bps:   .ds.l   1      Bytes/physical sector
pspal: .ds.l   1      Phys. sectors/alloc. unit
```

$39 MKDIR

```
C: int Dcreate(path)
   char *path;
```

A subdirectory can be created from the desktop with the menu option "NEW FOLDER". Such a subdirectory can also be created from an application program with a call to $39.

In order to create a new folder, the function $39 is given the address of the folder name, also called the pathname. This name may consist of 8 characters and a three-character extension. The same limitations apply to pathnames as do to filenames. The pathname must be terminated with a zero byte when calling MKDIR.

After the call, D0 indicates whether the operation was performed successfully. If D0 contains a zero, the call was successful. Errors are indicated through a negative number in D0. At the end of this chapter you will find an overview of all of the error messages occurring in connection with GEMDOS functions.

```
move.l pathname        Address of the pathname
move   #$39,-(sp)      Function number
trap   #1
addq.l #6,sp           Repair stack
tst.w  d0              Error occurred?
bne    error           Apparently
.
pathname:
       .dc.b  'private.dat',0
```

$3A RMDIR

```
C: int  Ddelete(path)
   char *path;
```

A subdirectory created with MKDIR can be removed with $3A. As before, the pathname, terminated with a zero, is passed to RMDIR. The error messages also correspond to those for MKDIR, with zero for success or a negative value for errors. An important error message should be mentioned at this point. It is the message -36 ($FFFFFFCA). This is the error message you get when the subdirectory you are trying to remove contains files.

Only empty subdirectories can be removed with RMDIR. If you get an error, erase directory files with UNLINK ($41), then call RMDIR again.

```
pea  pathname          Address of the pathname
move.w #$3A,-(sp)         Function #
trap   #1
addq.l #6,sp           Repair stack
tst.w   D0               Is there an error?
bne  era_sub_dir      It appears that way
.
pathname:
    .dc.b  'tmpfiles.a_z',0
```

$3B CHDIR

```
C: int Dsetpath(path)
   char *path;
```

The system of subdirectories available under GEMDOS is exactly the same form available under UNIX. This system is now running on systems with diskette drives, but its advantages become noticeable first when a large mass storage device such as a hard disk with several megabytes of storage capacity is connected to the system. After a while, most of the time would probably be spent looking for files in the directory.

To better organize the data, subdirectories can be placed within subdirectories. It can therefore become necessary to specify several subdirectories until one has the directory in which the desired file is stored. An example might be:

```
\hugos.dat\cfiles.s\csorts.s\cqsort.s
```

Translated this would mean: load the file `cqsort.s` from the subdirectory `csorts.s`. This subdirectory `csorts.s` is found in the subdirectory `cfiles.s`, which in turn is a subdirectory of `hugos.dat`. If the whole expression is given as a filename, the desired file will actually be loaded (assuming that the file and all of the subdirectories are present). If you want to access another file via the same path (do you understand the term pathname?), the entire path must be entered again. But you can also make the subdirectory specified in the path into the current directory, by calling CHDIR with the specification of the desired path. After this, all of the files in the selected subdirectory can be accessed just by the filenames. The path is set by the function.

```
move.l path,-(sp)     Address of the path
move.w #$3b,-(sp)     Function number
trap   #1
addq.l #6,sp          Repair stack
tst.w  d0             Error occurred?
bne    error          Apparently
.
.
path:
      .dc.b  ' \hugos.dat\cfiles.s\csorts.s\cqsort.s',0
```

$3C CREATE

```
C: int  Fcreate(fname,attr)
   char *fname;
   int  attr;
```

In all operating systems, the files are accessed through the sequence of opening the file, accessing the data (reading or writing), and then closing the file. This "trinity" also exists under GEMDOS, although there is an exception. Under CP/M, for example, a non-existent file can also be opened. When a file which does not exist is opened, it is created. Under GEMDOS, the file must first be created. The call $3C, CREATE, is used for this purpose. Two parameters are passed to this GEMDOS function: the address of the desired filename, and an attribute word.

If a zero is passed as the attribute word, a normal file is created, a file which can be written to as well as read from. If the value 1 is passed as the attribute the file will only be able to be read after it is closed. This is a type of software write-protect (which naturally cannot prevent the file from disappearing if the disk is formatted).

Other possible attributes are $02, $04, and $08. Attribute $02 creates a "hidden" file and attribute $04 a "hidden" system file. Attribute $08 creates a file with a "volume label." The volume label is the (optional) name which a disk can be given when it is formatted. The disk name is then created from the maximum of 11 characters in the name and the extension. Files with one of the last three attributes are excluded from the normal directory search in the Desktop. On the ST, however, they appear in the directory, e.g. as COMMAND.PRG.

When the function CREATE is ended, a file descriptor, also called a file handle, is returned in D0. All additional accesses to the file take place over this file handle (a numerical value between 6 and 45). The handle must be given when reading, writing, or closing files. A total of $28 = 40 files can be opened at the same time.

If CREATE is called and a file with this name already exists, it is cut off at zero length. This is equivalent to the sequence delete the old file and create a new file with the same name, but it goes much faster.

If after calling CREATE you get a handle number back in D0, the file need not be opened again with $3D OPEN.

```
move.w #$0,-(sp)       File should have R/W status
pea    filename        Address of the filename on stack
move.w #$3c,-(sp)      Fcreate function number
trap   #1              Call GEMDOS
addq.l #8,sp           Clean up stack
tst    d0              Error occurred?
bmi    error           It appears so
move   d0,handle       Save file handle for later access
.
filename:                      Don't forget the zero byte
       .dc.b  'myfile.dat',0
.
handle:
       .ds.w  1
```

$3D OPEN

```
C: int Fopen(fname,mode)
   char *fname;
   int mode;
```

You can only create new files with CREATE, or shorten existing files to zero length. But you must be able to process existing files further as well. To do this, such files must be opened with the OPEN function.

The first parameter of the OPEN function is the mode word. With a zero in the mode word, the opened file can only be read, with one it can only be written. With a value of 2, the file can be read as well as written. The filename, ended with a zero byte, is passed as the second parameter.

The OPEN function returns the handle number in D0 as the result if the file is present and the desired access mode is possible. Otherwise D0 contains an error number. See the end of the chapter for a list of the error numbers.

Up until now, when we've discussed file functions, we have referred only to files. This is only half the story; devices can be opened and closed as well as files. These devices are the console (keyboard) and monitor, the serial port and the printer connection. See Chapter 3.1.1 for more information on GEMDOS and the file/device concept. We want to show you for now how a device is opened, and what handle to give it. This information is important insofar as device handles are different from file handles.

To open a device, the device name is given as a filename. The device names are: "CON:" for the console, "AUX:" for the serial interface and "PRN:" for the printer interface. After opening with the appropriate name, you'll get a word-negative handle. $FFFF(-1) is returned for CON:, $FFFE(-2) is returned for AUX: and $FFFD(-3) is the handle for the printer port.

```
move.w #$2,-(sp)      File read and write
pea filename          Address of the filename on the stack
move.w #$3d,-(sp)     Function number
trap   #1             Call GEMDOS
addq.l #8,sp          Clean up the stack
tst.l  d0             Error occurred?
bmi    error          Apparently
move   d0,fhandle     Save file handle for later accesses
.
filename:             Don't forget zero byte!
       .dc.b   'myfile.dat',0
handle:
       .ds.w   1
```

$3E CLOSE

```
C: int  Fclose(handle)
   int  handle;
```

Every opened file should be closed when it is no longer needed within a program, or when the program itself is ended. Especially when writing, files must absolutely be closed before the program ends or data may be lost.

Files are closed by the call CLOSE, to which the handle number is passed as a parameter. The return value will be zero if the file was closed correctly.

```
move.w handle,-(sp)   Handle number
move.w #$3e,-(sp)     Function number
trap   #1             Call GEMDOS
addq.l #4,sp          Error occurred?
bmi    error          Apparently
.
handle:
       .ds.w   1
```

$3F READ

```
C: long Fread(handle, count, buff)
   int  handle;
   long count;
   char *buff;
```

Opening and closing files is naturally only half of the matter. Data must be stored and the retrieved later. Reading such files can be done in a very elegant manner with the function READ. READ expects three parameters: first the address of a buffer in which the data is to be read, then the number of bytes to be read from the file, and finally the handle number of the file. This number you have (hopefully) saved from the previous OPEN.

As return value, D0 contains either an error number (hopefully not) or the number of bytes read without error. No message regarding the end of the file is returned. This is not necessary, however, since the size of the file is contained in the directory entry (see SEARCH FIRST/SEARCH NEXT). If the file is read past the logical end, no message is given. The reading will be interrupted at the end of the last occupied allocation unit of the file. The number of bytes read in this case is always divisible by $400.

```
pea     buffer          Address of the data buffer
move.l  #$100,-(sp)     Read 256 bytes
move.w  handle,-(sp)    Space for the handle number
move.w  #$3f,-(sp)      Function number
trap    #1
add.l   #12,sp
tst.l   d0              Did an error occur
bmi     error           Apparently
cmp.l   #$100,d0        256 bytes read?
bne     end_of_file     Not enough data in file
.
.
handle:
        .ds.w  1        Space for the handle number
.
buffer:
        .ds.b  $100     Suffices in our example
```

$40 WRITE

```
C: long Fwrite(handle, count, buff)
   int   handle;
   long count;
   char *buff;
```

Writing to a file is just as simple as reading from it. The parameters required are also the same as those required for reading. The file descriptors from OPEN and CREATE calls can be used as the handle, but the device numbers listed for READ can also be used. The output of a program can be sent to the screen, the printer, or in a file just by changing the handle number.

```
pea     buffer          Address of the data buffer
move.l #$100,-(sp)      Read 256 bytes
move.w handle,-(sp)     Space for the handle number
move.w #$40,-(sp)       WRITE request
trap    #1
add.l   #12,sp
tst.l   d0              Did an error occur?
bmi     error           Apparently
 .
 .
handle:
        .ds.w   1       Space for the handle number
 .
buffer:
        .ds.b   $100    Suffices in our example
```

$41 UNLINK

```
C: int  Fdelete(fname)
   char *fname;
```

Files which are no longer needed can be deleted with UNLINK. To do this, the address of the filename or, if necessary, the complete pathname must be passed to the function. If the D0 register contains a zero after the call, the file has been deleted. Otherwise D0 will contain an error number.

```
pea     fname           Name of the file to be scratched
move.w  #$41,-(sp)      Function number Fdelete()
trap    #1
add.l   #6,sp
tst.l   d0              Did an error occur?
bmi     error           Apparently
.
.
fname:
        .dc.b    'b:\hugos.dat\cfiles\csorts\cqsort.s',0
```

$42 LSEEK

```
C: long Fseek(offset, handle, seekmode)
   long offset;
   int  handle;
   int  seekmode;
```

Up to now we have become acquainted only with sequential data accesses. We can read through any file from the beginning until we come the desired information. An internal file pointer which points to the next byte to be read goes along with each read. We can only move this pointer continuously in the direction of the end of file by reading. A few bytes forward or backward, setting the pointer as desired, is not something we can do. This is required for many applications, however.

LSEEK offers an extraordinarily easy-to-use method of setting the file pointer to any desired byte within the file and to read or write at this point.This UNIX-compatible option of GEMDOS is much easier to use than the relative file management methods available under CP/M, for instance.

A total of three parameters are passed to the LSEEK function. The first parameter specifies the number of bytes by which the pointer should be moved. An additional parameter is the handle number of the file. The last parameter is a mode word which describes how the file is to be moved. A zero as the mode moves the pointer to the start of the file and from there the given number of bytes toward the end of the file. Only positive values may be used as the number. With a mode value of 1, the pointer is moved the desired positive or negative amount from the current position, and a 2 as the mode value means the distance specified is from the end of the file. Only negative values are allowed in this mode.

After the call, D0 contains the absolute position of the pointer from the start of the file, or an error message.

```
move.w #1,-(sp)      Relative from the current file ptr
move.w handle,-(sp)  File handle
move.l #$-20,-(sp)   32 bytes back
move.w #$42,-(sp)    Function number
trap   #1
add.l  #10,sp
tst.w  d0            Did an error occur?
bmi    error         Apparently
.
.
handle:
       .ds.w  1      Space for the handle number
```

$43 CHANGE MODE (CHMOD)

```
C: int  Fattrib(fname, flag, attrib)
   char *fname;
   int  flag;
   int  attrib;
```

With the CREATE function a file can be assigned a specific attribute. This attribute can be determined and subsequently changed only with the function CHANGE MODE. The name of the file must be known because the address of the name or the complete pathname must be passed to CHMOD. Another parameter word specifies whether the file attribute is to be read or set. Moreover, a word must be passed which contains the new attribute. When reading the attribute of a file this word is not necessary, but should be passed to the routine as a dummy value. We indicated the possible file attributes in our discussion of the function CREATE, but here they are again in a table:

```
$00 = normal file status, read/write possible
$01 = File is READ ONLY
$02 = "hidden" file
$04 = system file
$08 = file is a volume label, contains disk name
$10 = file is a subdirectory
$20 = file is written and closed correctly
```

Attributes $10 and $20 cannot be specified when the file is created. Attribute $20 is given by the operating system, while the GEMDOS function MKDIR is used to create a subdirectory. The MKDIR function not only creates the directory entry with the appropriate attribute, it also physically arranges the subdirectory on the disk.

After the call, D0 will contain the current attribute value, which will be the new value after setting the attribute, or a negative error number.

First example:

```
move.w #1,-(sp)       Give file READ ONLY attribute
move.w #1,-(sp)       Set attribute identifier
pea     pathname      We also need the pathname
move.w #$43,-(sp)     Function number
trap   #1
add.l  #10,sp
tst.w  d0             Did an error occur?
bmi    error          Apparently
.
pathname:             Don't forget zero byte at end!
       .dc.b  'killme.not',0
```

Second example:

```
move.w #0,-(sp)       Dummy value, not actually required
move.w #0,-(sp)       Read attribute
pea    pathname       and the pathname
move.w #$43,-(sp)     Function number
trap   #1
add.l  #10,sp
tst.w  d0             Did an error occur?
bmi    error          Apparently
.
.
.
pathname:             Don't forget zero byte at the end!
       .dc.b  'what-am.i',0
```

$45 DUP

```
C: int  Fdup(handle)
   int  handle;
```

As mentioned in connection with the functions READ and WRITE, the devices console, line printer and RS-232 are available to the programmer. This permits input and output to be redirected to these devices. One of the devices can be assigned a file handle number with the DUP function. After the call the next free handle number is returned.

```
move.w STDH,-(sp)   Parameter is standard handle number (0-5)
move.w #$45,-(sp)   Execute DUP
trap   #1
addq.l #4,sp
tst.l  d0           -35,-37 or 0 are possible
bmi    DUPERR
move   d0,NSTDH     Result is non standard handle
.                   number (6-45)
```

$46 FORCE

```
C: int  Fforce(stdh,nonstdh)
   int  stdh;
   int nonstdh;
```

The FORCE function allows further manipulation of handle numbers. If in a program the console input and output are used exclusively via the READ and WRITE functions with the handle numbers 0 and 1, input or output can be redirected with a call to this function. Screen outputs are written to a file, inputs are not taken from the keyboard, but from a previously-opened file.

```
move.w NSTDH,-(sp)   Parameter is non-standard handle
move.w STDH,-(sp)    Standard handle (0-5)
move.w #$46,-(sp)    Execute FORCE
trap   #1
addq.l #6,sp
tst.l  d0            -37 or 0 are possible
bne    FORCE_ERR
```

$47 GETDIR

```
C: void Dgetpath(buf, drive)
   char *buf;
   int  drive;
```

A given subdirectory can be made into the current directory with the function $37. All file accesses with a pathname then run only in the set subdirectory. Under certain presumptions it can be possible to determine the pathname to the current subdirectory. This is accomplished by the function call GETDIR, $47. This call requires the designation of the desired disk drive (0=current drive, 1=drive A, 2=drive B, etc.) and a pointer to a 64-byte buffer. The complete pathname to the current directory will be placed in this buffer. The pathname will be terminated by a zero byte. If the function is called when the main directory is active, no pathname will be returned. In this case, the first byte in the buffer will contain zero. After the call, D0 must contain the value zero. If the value is negative, an error occurred, for example if an incorrect drive number was passed.

```
move.w #0,-(sp)         Get pathname of the current drive
pea    buffer           Address of the 64-byte buffer
move.w #$47,-(sp)       Function number
trap   #1
addq.l #8,sp
.
.
buffer:
       .ds.b   128      Better to play it safe
```

$48 MALLOC

```
C: long Malloc(number)
   long number;
```

The MALLOC function and the two that follow it, MFREE and SETBLOCK, are concerned with the memory organization of GEMDOS. As already mentioned in conjunction with function $31, KEEP PROCESS, a program is assigned all of the entire memory space available after it is loaded. This is uncritical in many cases, because only a single program is running.

There are applications under GEM in which at least a part of memory is free from the start of the program, to allow memory to be called for different GEM functions with MALLOC. One good example is the item selector box, which will not appear when no more memory is available.

Other applications are programs which work with overlays, for example. To load an overlay from the diskette, GEMDOS must have memory available. For this reason, every program must only have enough memory reserved for program and data code. The unused memory can then be returned to GEMDOS by the SETBLOCK command.

If the program needs some of the memory it released, it can request memory from GEMDOS via the function MALLOC (memory allocate). The number of bytes required is passed to MALLOC. After the call, D0 contains the starting address of the memory area reserved by the call or an error message if an attempt is made to reserve more memory than is actually available.

If -1L is passed as the number of bytes to be allocated, the number of bytes available is returned in D0.

Example 1:

```
move.l #-1,-(sp)        Determine number of free bytes
move.w #$48,-(sp)       Function number
trap   #1
addq.l #6,sp            Number of free bytes in D0
.
```

Example 2:

```
move.l #$1000,-(sp)     Get hex 1000 bytes for the program
move.w #$48,-(sp)       Function number
trap   #1
addq.l #6,sp
tst.l  d0              Error or address of memory?
bmi    error           Negative long word = error!
move.l d0,mstart       Else start addr of the reserved area
.
mstart:
       .ds.l   1
```

$49 MFREE

```
C: long Mfree(addr)
   long addr;
```

An area of memory reserved with MALLOC can be released at any time with MFREE. To do this, GEMDOS is passed the address of the memory to be released. The value will usually be the address returned by MALLOC.

If a value of zero is returned in D0, the memory was released by GEMDOS without error. Negative values indicates errors.

```
move.l mstart,-(sp)      Addr of a previously allocated area
move.w #$49,-(sp)        Function number
trap   #1
addq.l #6,sp             Number of free bytes in D0
tst.l  d0                Error?
bne    error             D0<>0 is error!
.
.
mstart:
       .ds.l  1
```

$4A SETBLOCK

```
C: int  Mshrink(dummy, block, newsize)
   word dummy = 0;
   long block;
   long newsize;
```

In contrast to the MALLOC function, a specific area of memory can be reserved with the function SETBLOCK. The memory beginning at the specified address is returned to GEMDOS, even if it was reserved before. This function can be used to reserve the actual memory requirements of a program and release the remaining memory.

The parameters the function requires are the starting address and the length of the area to be reserved. The area specified with these parameters is then reserved by GEMDOS and is not released again until the end of the program or after calling the MFREE function.

Usually programs will begin with the following command sequence or something similar. After the call, D0 must contain zero, otherwise an error occurs.

```
move.l a7,a5          Save stack pointer in A5
move.l #ustck,a7      Set up stack for the program
move.l 4(a5),a5       A5 now points to the base-page start
                      exactly $100 bytes below the prg start
move.l $c(a5),d0      $C(A5) contains length of the prg area
add.l  $14(a5),d0     $14(A5) containing the length of the
                      initialized data area
add.l  $1C(a5),d0     $1C(A5) contains length of the
                      uninitialized data area
add.l  #$100,d0       Reserve $100 bytes base page
move.l d0,-(sp)       D0 contains the length of the area
                      to be reserved
move.l a5,-(sp)       A5 contains the start of the area
                      to be reserved
move.w #0,-(sp)       Meaningless word, but still necessary!
move.w #$4a,-(sp)     Function number
trap   #1
add.l  #12,sp         Clean up the stack as usual
tst.l  d0             Did an error occur?
bne    error          Stop
.                     Here the program continues...
```

$4B EXEC

```
C: long Pexec(mode, ptr1, ptr2, ptr3)
   int  mode;
   char *ptr1;
   char *ptr2;
   char *ptr3;
```

The Pexec() function permits loading and chaining programs. If desired, the program loaded can be automatically started. In addition to the function number, the addresses of three strings and a mode word are expected on the stack.

Let's talk a bit about the mode word. This word has a value of 0, 3, 4 or 5.

Mode=0 represents the LOAD'N'GO option: In this case, the file is loaded from diskette and the filename and pathname are received in PTR1. PTR2 contains the option of the command tail, comparable to choosing .TTP in a dialog box. PTR2 stands for the environment string, which apparently has no function under GEMDOS. If the command tail and the environment string aren't used, then there is a null-byte at this point.

After loading the program, the system automatically starts the program. The called program, started by the Pexec() call, remains in memory. Eventually opened files will pass on the most recently started program. This new program will be classified as a "child process." Once the child process is done, control returns to the original program, or "parent process."

If the mode word is a three, the parameters PTR1 to PTR3 are handled in the same form as when mode = 0, except that the program will not be executed once it is loaded into memory. After calling Pexec() with mode = 3, the address of the basepage of the loaded program is found in D0.

At first glance this may not make sense, but this function is the minimum that any good debugger should have. When you want to search a program for errors with a debugger, you would want control to go to the debugger, instead of the program loading and immediately executing. If the program ran without the debugger, and it had errors, it would crash. The LOAD option of Pexec() offers help.

If the mode word = 4, the program found in memory will be started. PTR1 waits for the address of the necessary basepage. PTR2 and PTR3 are unused. This way you can start a program previously loaded with Pexec(), mode = 3.

The last option is a mode word of 5. This option sets up the basepage in memory, as well as allocating the largest free block of memory. Naturally, no more data can go into the basepage after this call, especially text, data and BSS ranges. These must be provided for by the programmer.

```
pea     env             Environment
pea     com             Command line
pea     fil             Filename
move.w  #0,-(sp)        Load and start, please
move.w  #$4b,-(sp)      Function number
trap    #1
add.l   #16,sp          Here we come to the end of the
.                       chained program or loaded module
```

```
fil:                    Load sort routine
        .dc.b  'qsort.prg',0
com:                    Sort the file in ascending order
        .dc.b  'up data.asc',0
env:                    No environment
        .dc.w  0
.
```

$4C TERM

```
C: void Pterm(retcode)
   int  retcode;
```

TERM $4C represents the third method, after Pterm0(), function number $00, and Ptermres(), function number $31, of ending a program. Pterm() automatically makes the memory used by the program available to GEMDOS again. Unlike TERM $00, however, a programmer-defined value other than zero can be returned to the caller. This allows a short message to be passed back to the calling program.

All files opened in this process will be automatically closed from PTERM.

```
move.w #37,-(sp)     Any 2-byte value
move.w #$4c,-(sp)    End program
trap   #1                    ...now
.                    We never get here
```

$ 4E SFIRST

```
C: int  Fsfirst(fnam,attr)
   char *fnam;
   int  attr;
```

The SFIRST function can be used to check to see if a file with the given name is present in the directory. If a file with the same name is found, the filename, the file attribute, data and time of creation, and the size of the file in bytes is returned. This information is placed in the DTA buffer, whose address is set with the SETDTA function, by GEMDOS.

One feature of this function is that the filename need not be specified in its entirety. Individual characters in the filename can be exchanged for a question mark "?", and entire groups of letters can also be replaced by a "*". In the extreme form a filename would be reduced to the string "*.*". In this case the first file in the directory would satisfy the conditions and the filename would appear in the DTA buffer along with the other information.

In addition to the filename, the SFIRST function must also be given a search attribute. The possible parameters of the search attribute correspond to the attributes which can be specified in CHMOD function:

```
$00 = Normal access, read/write possible
$01 = Normal access, write protected
$02 = Hidden entry (ignored by the ST desktop)
$04 = Hidden system file (ignored like $02)
$08 = Volume label, diskette name
$10 = Subdirectory
$20 = File will be written and closed
```

The following rules apply when searching for files:

- If the attribute word is zero, only normal files are recognized. System files or subdirectories are not recognized.
- System files, hidden files, and subdirectories are found when the corresponding attribute bits are set. Volume labels are not recognized, however.
- In order to get the volume label, this option must be expressly set in the attribute word. All other files are then ignored.
- After the call, D0 contains zero if the desired file has been found. The 44-byte DTA buffer is then constructed as follows:

```
Bytes    0-20       Reserved for GEMDOS
Byte     21         File attribute
Bytes    22-23      Clock time of file creation
Bytes    24-25      Date of file creation
Bytes    26-29      File size in bytes (long)
Bytes    30-43      Name and extension of the file
```

If, however, no file is found which corresponds to the specified search string, the error message -33, file not found, is returned.

```
pea     dta             Set up DTA buffer
move.w #1a,-(sp)        Function number SETDTA
```

```
trap    #1
addq.l  #6,SP
move.w  #attrib,-(sp)   Attribute value
move.l  #filnam,-(sp)   Name of file to search for
move.w  #$4e,-(sp)      Function number
trap    #1
addq.l  #8,sp
tst     d0              File found?
bne     notfound        Apparently not
.
.
attrib:
        .dc.b   0       Search for normal files only
filnam:
        .dc.b   '*.*',0 Search for the 1st possible file
.
.
dta:
        .ds.b   44      Space for the DTA buffer
```

$4F SNEXT

`C: int  Fsnext()`

The SNEXT function (Search next) can be used to see if there are other files on the disk which match the filename given. To do this, only the function number need be passed; SNEXT does not require any parameters. All of the parameters are set from the SFIRST call.

If the search string is very global, as in the previous example, all of the files on a diskette can be determined and displayed one after the other with SFIRST and SNEXT. This makes it rather easy to display a directory within a program. The SNEXT function is called repeatedly and the contents of D0 are check afterwards. If D0 contains a value other than zero, either an error occurred, or all of the directory entries have been searched.

```
move.w  #$4f,-(sp)      Search next
trap    #1              Is it still there?
addq.l  #2,sp
tst.l   d0              No more by negative values
```

$56 RENAME

```
C: int  Frename(dummy, oldname, newname)
   int  dummy = 0;
   char*oldname;
   char *newname;
```

Files are renamed under GEMDOS with the RENAME function, which requires two pointers to file or pathnames. The first pointer points to the new name, with the specification of the pathname if necessary; the second pointer points to the previous name. A 2-byte parameter is required in addition to the two pointers. We were unable to determine the function of the additional word parameter. Different values had no (recognizable) effect.

As a return value, D0 contains either zero, meaning that the name was changed correctly, or an error code.

```
pea     newnam              New filename
pea     oldname             File to rename
move.w  #0,-(sp)            Dummy
move.w  #$56,-(sp)          Function number
trap    #1
add.l   #12,sp
tst.l   d0                  Test for error
.
oldnam:                     Don't forget zero byte at end!
        .dc.b  'oldfile.dat',0
newnam:
        .dc.b  'newname.dat',0
```

$57 GSDTOF

```
C: void Fdatime(timeptr, handle, flag)
   int  handle;
   char *timeptr;
   int flag;
```

If the directory is displayed as text rather than icons on the desktop, the date and time of file creation as well as the size of the file in bytes is shown. The time and date can either be set or read with function $57. To do this it is necessary that the file be already opened by OPEN or CREATE. The handle

number obtained at the opening must be passed to the function. Additional parameters are a word which acts as a flag as to whether the time and date are to be set (0) or read (1), and a pointer to a 4-byte buffer which either contains the result or will be provided with the required data before the call.

This date buffer contains the time in the first two byes and the date in the last two bytes. The data format is identical to that of the functions for setting/reading the time and date.

A word of warning about this section. Programmers who call this function in C and assembler must make allowances. In the include file OSBIND.H, the parameters 'timeprt' and 'handle' are exchanged. A C call must follow this scheme when using the abovementioned include file. In assembler programs, however, the normal sequence of parameters must be followed.

Example 1:

```
move.w #1,-(sp)         Read time and date
pea    buff             4 byte buffer
move.w #handle,-(sp)    File must first be opened
move.w #$57,-(sp)       Function number
trap   #1
add.l  #10,sp
handle:
       .ds.b  2
buff:
       .ds.b  4
```

Example 2:

```
move.w #0,-(sp)         Set time and date
pea    buff             4 byte buffer
move.w #handle,-(sp)    File must first be opened
move.w #$57,-(sp)       Function number
trap   #1
add.l  #10,sp
handle:
       .ds.b  2
buff:
       .ds.b  4
```

3.1.1 Memory, files and processes

Will it never end? You just mastered getting around the operating system of your C-64, Atari 800 or other 8-bit machine, then suddenly you're confronted with new things such as memory management, handles, and even parent/child processes. Other computers don't have these knickknacks. Is it really that important to have them? Doesn't the computer run fine without them? And then there are these types that don't stay at the memory address you want them to operate. It was so much simpler in the past. Those were the days when you knew where a program loaded and ran, and when you assembled things at the necessary addresses.

I/O conversion, Malloc, basepage, Pexec or Dup are such obscure terms. Yes, everything was a lot simpler in the good old days.

We're here to help you overcome the "culture shock" that hits most 8-bit owners when they get a 16-bit computer. In order to ease you into the most effective use of the Atari ST operating system, we want to show you what special functions like MALLOC, SETBLOCK, TERM and PEXEC are, as well as the use and design of the basepage. We'll close with DUP and FORCE, the input/output division.

The concept of memory processing

When the ST is first turned on, it goes through a normal boot sequence. This sequence happens regardless of the ROMs or operating system in your ST. The system boots, then displays the Desktop on the monitor.

Up to this time there have already been a number of procedures done within the ST. So other memory, peripheral chips and operating system routines are initialized, and the programs in the Auto folder executed.

The Desktop itself is an independent program, the same as an editor, BASIC interpreter or compiler. Whether it is in ROM or on the TOS.IMG disk, it starts like a program loaded from disk. One specific task of the Desktop is to load other programs and give computer control to these programs. As we said earlier, we'll take a closer look.

The function call Pexec is used by the Desktop in loading programs. When you choose a program with the mouse, a corresponding Pexec call with the filename and parameters given in the dialog box is executed. GEMDOS

takes control from the call and looks for free memory. But what's "free memory"? Every program has its memory range; free memory is unoccupied memory, into which a program can be loaded. The start of free memory (TPA) will then have a basepage added to it. This basepage is 256 bytes ($100 bytes) in size, and contains special information about the program being loaded. The basepage's design looks like this:

Offset	Identifier	Function
0x00	p_lowtpa	Pointer to start of basepage
0x04	p_hitpa	Pointer to the end of free memory
0x08	p_tbase	Pointer to beginning of program (text segment)
0x0c	p_tlen	Program size (Text segment)
0x10	p_dbase	Pointer to start of data segment
0x14	p_dlen	Data segment size
0x18	p_bbase	Pointer to beginning of BSS segments
0x1c	p_len	BSS segment size
0x20	p_dta	Pointer to DTA buffer
0x24	p_parent	Pointer to parent's basepage
0x28	(reserved)	
0x2c	p_env	Pointer to environment string
0x80	cmdlin	Command line

The range between 0x30 and 0x7f is used by the operating system. You should not use this range.

Although the basepage is sent from the system, there aren't many other things that need to be done. First, after the program is loaded directly behind the basepage, the data is made available and put into the appropriate areas.

The program is relocated after loading (if needed). The programmer as a rule has no control over the memory where the program resides, since Pexec controls the free memory, and loads the program into that memory. The classic 8-bit computer must load a program into a specific range of memory, which easily allows combining multiple programs into one memory register. These combinations should be avoided at all costs under "proper" GEMDOS programming. Instead, assemble the program, putting relevant addresses into a loader that Pexec will load first, then act upon these addresses before loading the main program.

The program will start after this work. It is now a child of a program that it has called. The calling program will be identified as a parent. This parent has no gender; the general reference of parent and child solves any linguistic problems.

For the moment, let's concentrate on the child. This process has from the first set up the entire free memory needed. The first action should be to determine the amount of memory needed in any program, and hand the rest over to GEMDOS. And how do you allocate memory? Once you know it, it's simple to follow.

After the start of the program, you'll find the address of the basepage on the stack. All the program data and calculations for memory requirements is in the basepage. These data are p_tlen, p_dlen and p_blen. Add these values together, and there you have your range needed by the program. In addition, you have to reserve memory for the stack, which lies in protected memory.

When you analyze the beginning of a program with a disassembler, you'll frequently find the following or a similar sequence:

```
move.l a7,a5         store stack to determine basepage
move.l 4(a5),a5      base page is now in a5
move.l $c(a5),d0     text segment length stands in d0
add.l  $14(a5),d0    add to that the length of the data- and
add.l  $1c(a5),d0    the bss segments
add.l  #$500,d0      and to that add the amount needed for the stack

move.l d0,d1
add.l  a5,d1         length + address of basepage
and.l  #-2,d1        be sure that the stack starts at an even address
move.l d1,a7         now put the stack where you want it
move.l d0,-(sp)      size of reserved area
move.l a5,-(sp)      from where you want it reserved (base page)
clr.w  -(sp)         dummy
move.w #$4a,-(sp)    setblock-function number
trap   #1            call gemdos
add.l  #12,sp        and clear off the stack
```

This program section takes up all tasks which were demanded from GEMDOS. After GEMDOS has reduced the amount of available memory accordingly, the program can then continue.

What is released memory? This is done by GEMDOS for further Pexec calls. The child process has no access authority. You should ideally be able to use memory without further measurements. When you keep putting data into this range, the data could occasionally become "overstuffed". Different functions of GEMDOS, the VDI and AES are reserved by Malloc, and putting data into the received range. When you haven't protected your data, the chances are good that you'll lose your data.

When you have not set up available memory, then you can call Malloc from the operating system. After the call, you get the starting address of the reserved range. This range is "safe"—you can't put any other process into this range. When the memory is no longer free, the best thing to do is call Mfree. Then you can choose from another process.

When you hold to these conventions, then one can't get past. The memory is again protected, and you can load in any other programs. Every new loading makes up another child of the parent program. So overlaying programs is only allowed when the available memory is protected.

If a program ends with Pterm0 or Pterm, then the designated memory is released from the program. Additional memory reserved by Malloc will be released. Also, any open files will be closed. Then control returns to the parent, whereas it was previously held by the child.

Handles, files, devices

The basic file handling functions in GEMDOS are quite simple. Fopen or Fcreate open a file; this file is read from with Fread, and written to with Fwrite. Fclose closes the file. All file accesses run under a number, initially stated in Fopen or Fcreate. This number between 6 and 45 is called a "non standard handle." Non standard handles are used only in conjunction with files.

It is logical to assume that there are also "standard handles." And so there are; these are the handles between 0 and 5. These handles can be organized as either a file or as a "character device." Character devices in the ST consist of the keyboard, the monitor, the printer interface and the serial interface. Here is the normal assignment for these standard handles:

```
Handle    Device
  0       Console input (Stdin)
  1       Console output (Stout)
  2       Serial interface (AUX)
  3       Printer interface (PRN)
```

The standard handles 4 and 5 aren't used in ST GEMDOS as a rule. The "correct" GEMDOS layout sees handle 2 as a standard error device (Stderr). These will shift AUX and PRN over one place. Handle 5 is originally used as a null-device. This null-device can store output in an empty space. This setup is unfortunately not implemented in the ST.

That's not all. There are also character handles which are assigned in connection with the character devices. These character handles are received only after an Fopen or Fcreate, and give the names of the desired character devices. The names of the character devices are "CON:", "AUX:" and "PRN:".

Standard handles serve two distinct purposes. The first is that you can use them for Fopen or Fcreate without actually having Fopen or Fcreate. These handles will perform any process arranged by the parent process. The second purpose is the allowance for altering standard handles.

For example: You work on a program which waits for a quantity of data from the keyboard; this data is processed, saved to disk, and the results sent to a printer. Now, you could do every test run by hand, and end up with a pile of paper, until the program runs free of error. However, you could just as easily pass along the keyboard input and the printer output by writing all the keyboard input into a file, and having the file data do the typing. You could also have the printer output sent to a file instead of the printer, so you could save yourself a waste of paper, and still see the result later.

These conversions use both standard and non standard handles, controlled by the Force function. Here is a program fragment which contains the necessary calls for using a file to send "keyboard" input from a file:

```
move.w #0,-(sp)      "read only" mode
pea    fil_nam       name of the input file
move.w #$3d,-(sp)    fopen()
trap   #1            gemdos call
addq.l #8,sp
tst.l  d0            did fopen work?
bmi    opn_err       negative long is an error!
move.w d0,f_handle   the handle we need is our
move.w d0,-(sp)      our non std handle
move.w #0,-(sp)      std handle console
move.w #$46,-(sp)    force()
trap   #1            call gemdos
addq.l #6,sp
tst.l  d0            read error
bmi    frc_err
.
.                    input starts from
.                    file here
```

After this call (and this is extremely important), every GEMDOS call for a character from the keyboard will get it from the file. The keyboard must not

be read with Fread(). Cconin(), Crawio(), Cconrs() and the other functions dealing with keyboard data also look to the file data instead of the keyboard. The use of character functions (Conin, etc.) in connection with this are problematical. These functions have no options in working with the called program when the file ends. This information can be had only by using the Fread() function.

An exception is when you mark the input file with a special end-of-file (EOF) indicator. One character frequently used for this purpose is <Control><Z>, with an ASCII value of 26 or 0x1a. When you reserve this character for an EOF character, then you can read this character in addition to the standard arrangement of 0. For particularly elegant programming, you can follow it with the Fdup function. Here's a short example:

```
      move.w   #0,-(sp)        our std handle
      move.w   #$45,-(sp)      dup()
      trap     #1              call gemdos
      addq.l   #4,sp
      tst.l    d0              was there still a non std handle free?
      bmi      no_more         evidently not
      move.w   d0,dup_han      make a note of it!
      .
      .
*     here the key/file transfer program can follow
      .
      .
*     Here is the program itself. Now you can only start with keyboard
*     input
      .
      .
      move.w   dup_han,-(sp)   our non std handle from dup()
      move.w   #0,-(sp)        there should be a std handle
      move.w   #$46,-(sp)      force()
      trap     #1              call gemdos
      addq.l   #6,sp
      tst.l    d0              read error
      bmi      frc_err
      .
      .        from this point on, the input is again
      .        handed over to the keyboard
```

First, the handle from Stdin, the 0, is duplicated by the Dup function. The keyboard is accessed by the standard handle as well as the non standard handle. (only with Fread, naturally). The input routine then switches over to the file, giving the effect described above. All characters that you would

normally send over the keyboard are read from the file. When the input is ended, then the duplicated handle is returned to keyboard input with a Force call. The still open file should be closed by an Fclose call.

From reading the above, it should be clear to you the way that the printer output works. Again, open a file with Fcreate(). The handle used can be Forced from the printer. Then all data that would normally go to the printer will be sent to a file.

A further application would be when you move output from the screen to the printer. This can also be easily realized.

GEMDOS error codes and their meaning

The GEMDOS functions return a value giving information about whether or not an error occurred during the execution of the function. A value of zero means no error; negative values have the following meanings:

```
-32   Invalid function number
-33   File not found
-34   Pathname not found
-35   Too many files open (no more handles left)
-36   Access not possible
-37   Invalid handle number
-39   Not enough memory
-40   Invalid memory block address
-46   Invalid drive specification
-49   No more files
```

In addition to these error messages, the BIOS error messages may occur. These error messages have numbers -1 to -31 and are described in section 3.3

3.2 The BIOS Functions

The software interface between GEMDOS and the hardware of the computer is the BIOS (Basic Input Output System). The BIOS, as the name suggests, is concerned with the fundamental input/output functions. This includes screen output, keyboard input, printer output, RS-232 functions and, of course, disk input and output.

The BIOS functions are also available to user programs. The `TRAP` instruction of the 68000 processor is used to call them. Any data required is passed through the stack and the result of the function is returned in the D0 register. The machine language programmer should be aware that the contents of D0-D2 and A0-A2 are changed when calling BIOS functions; the remaining registers remain unchanged.

BIOS function calls are even simpler if you program in C. Here you can use simple function calls with the corresponding parameter lists. The function calls are stored as macros in an include file. In the examples, the definition of the function and its parameters in C will be shown. For assembly language programmers, the use is described in an example.

`TRAP #13` is reserved for the BIOS functions.

0 Getmpb *get memory parameter block*

```
C: void Getmpb(pointer)
   long pointer;
```

Assembler:

```
move.l  pointer,-(SP)
move.w  #0,-(SP)
trap    #13
addq.l  #6,sp
```

This function fills a 12-byte block whose address is contained in `pointer` with the memory parameter block. This block contains three pointers:

```
long   md_mfl          Memory free list
long   md_mal          Memory allocated list
long   md_rover        Roving pointer
```

The structures to which each pointer points are constructed as follows:

```
long   md_link         Pointer to next block
long   md_start        Start address of the block
long   md_length       Length of the block in bytes
long   md_own          Process descriptor
```

Example:

```
move.l #buffer,-(sp)   Buffer for MPB
move.w #0,-(sp)        getmpb
trap   #13             Call BIOS
addq.l #6,sp           Stack correction
```

We get the values $48E, 0, and $48E. The following data are at address $48E (for 1MB RAM):

```
m_link    0            No additional block
m_start   $3B900       Start address of the free memory
m_length  $3C700       Length of the free memory
m_own     0            No process descriptor
```

1 Bconstat *return input device status*

```
C: int Bconstat(dev)
   int dev;
```

Assembler:

```
move.w dev,-(sp)
move.w #1,-(sp)
trap   #13
addq.l #4,sp
```

This function returns the status of an input device, defined as follows:

```
Status 0       No characters ready
Status -1      (at least) one character ready
```

The parameter `dev` specifies the input device:

```
dev     Input device
 0      PRT:, Centronics interface
 1      AUX:, RS-232 interface
 2      CON:, Keyboard and screen
 3      MIDI, MIDI interface
 4      IKBD, Keyboard port
```

The following table lists the allowed accesses to these devices:

Operation	PRT:	AUX:	CON:	MIDI	IKBD
Input status	no	yes	yes	yes	no
Input	yes	yes	yes	yes	no
Output status	yes	yes	yes	yes	yes
Output	yes	yes	yes	yes	yes

This example waits until a character from the RS-232 interface is ready.

```
wait move.w #1,-(sp)        RS-232
     move.w #1,-(sp)        bconstat
     trap   #13
     addq.l #4,sp
     tst    d0              character available?
     beq    wait            no, wait
```

2 Bconin

read character from device

```
C: long Bconin(dev)
   int dev;
```

Assembler:

```
    move.w dev,-(sp)
    move.w #2,-(sp)
    trap   #13
    addq.l #4,sp
```

This function fetches a character from an input device. The parameter `dev` has the same meaning as in the previous function. The function returns when a character is ready.

The character received is in the lowest byte of the result. If the input device was the keyboard (`con`, 2), the key scan code is also returned in the lower byte of the upper word (see the description of the keyboard processor).

Example:

```
    move.w  #2,-(sp)        con
    move.w  #2,-(sp)        bconin
    trap    #13
    addq.l  #4,sp
```

3 Bconout

write character to device

```
C: void Bconout(dev, c)
   int dev, c;
```

Assembler:

```
    move.w c,-(sp)
    move.w dev,-(sp)
    move.w #3,-(sp)
    trap   #13
    addq.l #6,sp
```

This function serves to output a character "c" to the output device dev (meaning is the same as for the previous function). The function returns when the character has been outputted.

Example:

```
move.w #'A',-(sp)
move.w #0,-(sp)        PRT:
move.w #3,-(sp)        Bconout
trap   #13
addq.l #6,sp
```

The example outputs the letter "A" to the printer.

4 Rwabs *read and write disk sector*

```
C: long Rwabs(rwflag, buffer, number, recno,dev)
   long buffer;
   int rwflag, number, recno, dev;
```

Assembler:

```
move.w dev,-(sp)
move.w recno,-(sp)
move.w number,-(sp)
move.l buffer,-(sp)
move.w rwflag,-(sp)
move.w #4,-(sp)
trap   #13
add.l  #14,sp
```

This function serves to read and write sectors on the disk. The parameters have the following meanings:

rwflag	Meaning
0	Read sector
1	Write sector
2	Read sector, ignore disk change
3	Write sector, ignore disk change

The parameter `buffer` is the address of a buffer into which the data will be read from the disk or from which the data will be written to the disk. The buffer should begin at an even address, or the transfer will run very slowly.

The parameter `number` specifies how many sectors should be read or written during the call. The parameter `recno` specifies which logical sector the process will start with.

The parameter `dev` determines which disk drive will be used:

```
dev   Drive
 0    Drive A
 1    Drive B
 2+   Hard disk, RAM disk, network
```

The function returns an error code as the result. If this value is zero, the operation was performed without error. The returned value will be negative if an error occurred (please see the **Floprd** entry of the XBIOS listing for error codes and their meanings).

Example:

```
   move.w #0,-(sp)        Drive A
   move.w #10,-(sp)       Start at logical sector 10
   move.w #2,-(sp)        Read 2 sectors
   move.l #buffer,-(sp)   Buffer address
   move.w #0,-(sp)        Read sectors
   move.w #4,-(sp)        rwabs
   trap   #13
   add.l  #14,sp
   ...
buffer    ds.b  2*512
```

5 Setexec *set exception vectors*

```
C: long Setexec(number, vector)
   int  number;
   long vector;
```

Assembler:

```
   move.l vector,-(sp)
   move.w number,-(sp)
   move.w #5,-(sp)
   trap   #13
   addq.l #8,sp
```

The function `setexec` allows one of the exception vectors of the 68000 processor to be changed. The number of the vector must be passed in `number` and the address of the routine pertaining to it in `vector`. The function returns the old vector as the result. If you just want to read the vector, pass the value -1 as the new address. The 256 processor vectors as well as 8 vectors for GEM, which numbers $100 to $107 (address $400 to $41C) can be changed with this function.

Example:

```
   move.l #buserror,-(sp)
   move.w #2,-(sp)
   move.w #5,-(sp)
   trap   #13
   addq.l #8,sp
   ...
buserror  ...
```

6 Tickcal *return millisecond per tick*

```
C: long Tickcal()
```

Assembler:

```
move.w #6,-(sp)
trap   #13
addq.l #2,sp
```

This function returns the number of milliseconds between two system timer calls.

Example:

```
move.w #6,-(sp)
trap   #13
addq.l #2,sp
```

Result: 20 ms

7 Getbpb *get BIOS parameter block*

```
C: long Getbpb(dev)
   int dev;
```

Assembler:

```
move.w dev,-(sp)
move.w #7,-(sp)
trap   #13
addq.l #4,sp
```

This function returns a pointer to the BIOS Parameter Block of the drive `dev` (0=drive A, 1=drive B).

The BPB (BIOS Parameter Block) is constructed as follows:

```
int  recsiz   Sector size in bytes
int  clsiz    Cluster size in sectors
int  clsizb   Cluster size in bytes
```

```
int  rdlen    Directory length in sectors
int  fsiz     FAT size in sectors
int  fatrec   Sector number of the second FAT
int  datrec   Sector number of the first data cluster
int  numcl    Number of data clusters on the disk
int  bflags   Misc. flags
```

The function returns the address $3E3E for drive A and the address $3E5E for drive B. An address of zero indicates an error.

Example:

```
move.w #0,-(sp)      Drive A
move.w #7,-(sp)      getbpb
trap   #13
addq.l #4,sp
```

Here are the BPB data for 80 track single and double-sided disk drives:

Parameter	80 track SS	80 track DS
recsiz	512	512
clsiz	2	2
clsizb	1024	1024
rdlen	7	7
fsiz	5	5
fatrec	6	6
datrec	18	18
numcl	351	711

8 Bcostat *return output device status*

```
C: long Bcostat(dev)
   int  dev;
```

Assembler:

```
move.w dev,-(sp)
move.w #8,-(sp)
trap   #13
addq.l #4,sp
```

This function tests to see if the output device specified by `dev` is ready to output the next character. `dev` can accept the values which are described in function one. The result of this function is either -1 if the output device is ready, or zero if it must wait.

Example:

```
move.w #0,-(sp)        Printer ready?
move.w #8,-(sp)        bcostat
trap   #13
addq.l #4,sp
```

---

9 Mediach *inquire media change*

```
C: long Mediach(dev)
   int dev;
```

Assembler:

```
move.w dev,-(sp)
move.w #9,-(sp)
trap   #13
addq.l #4,sp
```

This function determines if the disk has been changed. The parameter `dev`, the drive number (0=drive A, 1=drive B), must be passed to the routine.

One of three values can occur as the result:

```
0     Diskette was definitely not changed
1     Diskette may have been changed
2     Diskette was definitely changed
```

Example:

```
move.w #1,-(sp)       Drive B
move.w #9,-(sp)       mediach
trap   #13
addq.l #4,sp
```

10 Drvmap *inquire drive status*

`C: long Drvmap()`

Assembler:

```
move.w #10,-(sp)
trap   #13
addq.l #2,sp
```

This function returns a bit vector which contains the connected drives. The bit number `n` is set if drive `n` is available (0 means A, etc.). Even if only one drive is connected, %11 is still returned, since two logical drives are assumed.

Example:

```
move.w #10,-(sp)      drvmap
trap   #13
addq.l #2,sp
```

11 Kbshift *inquire/change keyboard status*

```
C: long Kbshift(mode)
   int mode;
```

Assembler:

```
move.w mode,-(sp)
mode.w #11,-(sp)
trap   #13
addq.l #4,sp
```

With this function you can change or determine the status of the special keys on the keyboard. If `mode` is -1, you get the status, a positive value will be accepted as the status. The status is a bit vector constructed as follows:

```
Bit    Meaning
 0     Right shift key
 1     Left shift key
 2     Control key
 3     ALT key
 4     Caps Lock on
 5     Right mouse button (CLR/HOME)
 6     Left mouse button (INSERT)
 7     Unused
```

Example:

```
move.w #-1,-(sp)      Read shift status
move.w #11,-(sp)      kbshift
trap   #13
addq.l #4,sp
```

3.3 The XBIOS

To support the special hardware features of the Atari ST, there are extended BIOS (XBIOS) functions, which are called by a `TRAP#14` instruction. These functions, like the normal BIOS functions, can be called from assembly language as well as from C. When calling from C, a small TRAP handler in machine language is again necessary, which is contained in OSBIND and can look like this:

```
trap14:
      move.l  (sp)+,retsave  Save return address
      trap    #14            Call XBIOS
      move.l  retsave,-(sp)  Restore return address
      rts

      .bss
retsave  ds.l  1             Space for the return address
```

Macro functions can be used in C which allow the extended BIOS functions (eXtended BIOS, XBIOS) to be called by name. The appropriate function number and TRAP call will be created when the macro is expanded.

When working in assembly language, the function number of the XBIOS routine need simply be passed on the stack. The XBIOS has 40 different functions whose significance and use are described on the following pages.

0 Initmous *initialize mouse*

```
C: void Initmous(type, parameter, vector)
   int type;
   long parameter, vector;
```

Assembler:

```
move.l vector,-(sp)
move.l parameter,-(sp)
move.w type,-(sp)
move.w #0,(-sp)
trap   #14
add.l  #12,sp
```

This XBIOS function initializes the routines for mouse processing. The parameter `vector` is the address of a routine which will be executed following a mouse-report from the keyboard processor. The parameter `type` selects from among the following alternatives:

```
type
 0     Disable mouse
 1     Enable mouse, relative mode
 2     Enable mouse, absolute mode
 3     unused
 4     Enable mouse, keyboard mode
```

This allows you to select if mouse movements are to be reported and in what manner this will occur.

The parameter `parameter` points to a parameter block, which is constructed as follows:

```
char topmode
char buttons
char xparam
char yparam
```

The parameter `topmode` determines the layout of the coordinate system. A 0 means that Y=0 lies in the lower corner, 1 means that Y=0 lies in the upper corner.

The parameter `buttons` is a parameter for the command "set mouse buttons" of the keyboard processor (see description of the IKBD, intelligent keyboard).

The parameters `xparam` and `yparam` are scaling factors for the mouse movement. If you have selected 2 as the `type`, the absolute mode, the parameter block determines four more parameters:

```
int  xmax
int  ymax
int  xstart
int  ystart
```

These are the X- and Y-coordinates of the maximum value which the mouse position can assume, as well as the start value to which the mouse will be set.

Example:

```
     move.l #vector,-(sp)        Address of the mouse position
     move.l #parameter,-(sp)     Address of the parameter block
     move.w #1,-(sp)             Enable relative mouse mode
     move.w #0,-(sp)             Init mouse
     trap   #14
     add.l  #12,sp
     ...
parameter dc.b ......
     ...
vector    ...                    Mouse interrupt routine
```

1 Ssbrk *save memory space*

```
C: long Ssbrk(number)
   int number;
```

Assembler:

```
move.w number,-(sp)
move.w #1,-(sp)
trap   #14
addq.l #4,sp
```

This function reserves memory space. The number of bytes must be passed in `number`. Space is prepared at the upper end of memory. The function returns the address of the reserved memory area as the result. This function must be called before initializing the operating system, meaning that it must be called from the boot ROM, before the operating system is loaded.

Example:

```
move.w #$400,-(sp)      Reserve 1K
move.w #1,-(sp)         ssbrk
trap   #14
addq.l #4,sp
```

2 Physbase *return screen RAM base address*

```
C: long Physbase()
```

Assembler:

```
move    #2,-(sp)
trap    #14
addq.l #2,sp
```

This function returns the base of the physical screen RAM. The physical screen RAM is the area of memory displayed by the video shifter. The result is a long word.

Example:

```
$F8000, base address of the screen for 1 MB RAM
$78000, base address of the screen for 512 KB RAM
```

3 Logbase *set logical screen base*

```
C: long Logbase()
```

Assembler:

```
move    #3,-(sp)
trap    #14
addq.l #2,sp
```

The logical screen base is the address which is used for all output functions as the screen base. If the physical and logical screen bases are different, one screen will be displayed while another picture is being constructed in a different area of RAM, which will be displayed later. The result of this function call is again a longword.

Example:

```
$F8000, base address of the screen for 1 MB RAM
$78000, base address of the screen for 512 KB RAM
```

4 Getrez *return screen resolution*

```
C: int Getrez()
```

Assembler:

```
move.w #4,-(sp)
trap   #14
addq.l #2,sp
```

This function call returns the screen resolution:

```
0 :=  Low resolution, 320*200 pixels, 16 colors
1 :=  Medium resolution, 640*200 pixels, 4 colors
2 :=  High resolution, 640*400, pixels, monochrome
```

Example:

```
2, monochrome
```

5 Setscreen *set screen parameters*

```
C: void Setscreen(logadr, physadr, res)
   long logadr, physadr;
   int res;
```

Assembler:

```
move.w res,-(sp)
move.l physadr,-(sp)
move.l logadr,-(sp)
move.w #5,-(sp)
trap   #14
add.l  #12,sp
```

This function changes the screen parameters which can be read with the previous three functions. If a parameter should not be set, a negative value must be passed. The parameters are set in the next VBL routine so that no disturbances appear on the screen.

Example:

```
move.w #-1,-(sp)        Retain resolution
move.l #$70000,-(sp)    Physical base
move.l #$70000,-(sp)    Logical base
move.w #5,-(sp)         setscreen
trap   #14
add.l  #12,sp
```

Set the physical and the logical screen address to \$70000, retain the resolution.

6 Setpalette *set color palette*

```
C: void Setpalette(paletteptr)
   long paletteptr;
```

Assembler:

```
move.l paletteptr,-(sp)
move.w #6,-(sp)
trap   #14
addq.l #6,sp
```

A new color palette can be loaded with this function. The parameter `paletteptr` must be a pointer to a table with 16 colors (each a word). The address of the table must be even. The colors will be loaded at the start of the next VBL.

Example:

```
   move.l #palette,-(sp)    Address of the new color palette
   move.w #6,-(sp)          set palette
   trap   #14
   addq.l #6,sp
   ....
palette    dc.w   $777,$700,$070,$007,$111,$222,$333,$444
           dc.w   $555,$000,$001,$010,$100,$200,$020,$002
```

7 Setcolor *set color*

```
C: int Setcolor(colornum, color)
   int colornum, color
```

Assembler:

```
move.w color,-(sp)
move.w colornum,-(sp)
move.w #7,-(sp)
trap   #14
addq.l #6,sp
```

This function allows just one color to be changed. The color number (0-15) and the color belonging to it (0-$777) must be specified. If -1 is given as the color, the color is not set but the previous color is returned.

Example:

```
move.w #$777,-(sp)        Color white
move.w #1,-(sp)           As color number 1
move.w #7,-(sp)
trap   #14
addq.l #6,sp
```

8 Floprd *read diskette sector*

```
C: int Floprd(buffer, filler, dev, sector, track, side,
count)
   long buffer, filler;
   int  dev, sector, track, side, count;
```

Assembler:

```
   move.w count,-(sp)
   move.w side,-(sp)
   move.w track,-(sp)
   move.w sector,-(sp)
   move.w dev,-(sp)
   clr.l  -(sp)
   move.l buffer,-(sp)
   move.w #8,-(sp)
   trap   #14
   add.l  #20,sp
```

This function reads one or more sectors in from the diskette. The parameters have the following meaning:

`count:` Specifies how many sectors are to be read. Values between one and nine (number of sectors per track) are possible.

`side:` Selects the diskette side, zero for single-sided drives and zero or one for double-sided drives.

`track:` Determines the track number (0-79 for 80-track drives or 0-39 for 40-track drives).

`sector:` The sector number of the first sector to be read (0-9).

`dev:` Determine drive number, 0 for drive A and 1 for drive B.

`filler:` Unused long word.

`buffer:` Buffer in which the diskette data should be written. The buffer must begin on a word boundary and be large enough for the data to be read (512 bytes times the number of sectors).

The function returns an error code which has the following meaning:

```
  0  OK, no error
 -1  General error
 -2  Drive not ready
 -3  Unknown command
 -4  CRC error
 -5  Bad request, invalid command
 -6  Seek error, track not found
 -7  Unknown media (invalid boot sector)
 -8  Sector not found
 -9  (No paper)
-10  Write error
-11  Read error
-12  General error
-13  Diskette write protected
-14  Diskette was changed
-15  Unknown device
-16  Bad sector (during verify)
-17  Insert diskette (for connected drive)
```

Example:

```
    move.w #1,-(sp)           Read a sector
    move.w #0,-(sp)           Page zero
    move.w #0,-(sp)           Track zero
    move.w #1,-(sp)           Sector one
    move.w #1,-(sp)           Drive B
    clr.l  -(sp)
    move.l #buffer,-(sp)
    move.w #8,-(sp)           floprd
    trap   #14
    add.l  #20,sp
    tst    d0                 Did error occur?
    bmi    error              yes
    ...
buffer  ds.b 512              Buffer for a sector
```

9 Flopwr *write diskette sector*

```
C: int Floprd(buffer, filler, dev, sector, track, side,
              count)
   long buffer, filler;
   int  dev,sector,track,side,count;
```

Assembler:

```
    move.w count,-(sp)
    move.w side,-(sp)
    move.w track,-(sp)
    move.w sector,-(sp)
    move.w dev,-(sp)
    clr.l  -(sp)
    move.l buffer,-(sp)
    move.w #9,-(sp)
    trap   #14
    add.l  #20,sp
```

One or more sectors can be written to disk with this XBIOS function. The parameters have the same meaning as for the **Floprd** function. The function returns an error code which has the same meaning as for reading sectors.

Example:

```
    move.w #3,-(sp)           Write three sectors
    move.w #0,-(sp)           Side zero
    move.w #7,-(sp)           Track seven
    move.w #1,-(sp)           Sector one
    move.w #0,-(sp)           Drive A
    clr.l  -(sp)
    move.l #buffer,-(sp)      Address of the buffer
    move.w #9,-(sp)           flopwr
    trap   #14
    add.l  #20,sp
    tst    d0                 Did an error occur?
    bmi    error              yes
    ...
buffer  ds.b 3*512            Buffer for three sectors
```

10 Flopfmt *format diskette*

```
C: int Flopfmt(buffer, filler, dev, spt, track, side,
               interleave, magic, virgin)
   long buffer, filler, magic;
   int  dev, spt, track, side, interleave, virgin;
```

Assembler:

```
   move.w virgin,-(sp)
   move.l magic,-(sp)
   move.w interleave,-(sp)
   move.w side,-(sp)
   move.w track,-(sp)
   move.w spt,-(sp)
   move.w dev,-(sp)
   clr.l  -(sp)
   move.l buffer,-(sp)
   move.w #10,-(sp)
   trap   #14
   add.l  #26,sp
```

This routine serves to format a track on the diskette. The parameters have the following meanings:

`virgin:`	The sectors are formatted with this value. The standard value is $E5E5. The high nibble of each byte may not contain the value $F.
`magic:`	The constant $87654321 must be used as `magic` or formatting will be stopped.
`interleave:`	Determines in which order the sectors on the disk will be written, usually one.
`side:`	Selects the disk side (0 or 1).
`track:`	The number of the track to be formatted (0-79).
`spt:`	Sectors per track, normally 9.
`dev:`	The drive, 0 for A and 1 for B.

`filler:` Unused long word.

`buffer:` Buffer for the track data; for 9 sectors per track the buffer mst be at least 8K large.

The function returns an error code as its result. The value -16, bad sectors, means that data in some sectors could not be read back correctly. In this case the buffer contains a list of bad sectors (word data, terminated by zero). You can format these again or mark the sectors as bad.

Example:

```
    move.w  #$E5E5,-(sp)       Initial data
    move.l  #$87654321,-(sp)   magic
    move.w  #1,-(sp)           interleave
    move.w  #0,-(sp)           side 0
    move.w  #79,-(sp)          track 79
    move.w  #9,-(sp)           9 sector per track
    move.w  #0,-(sp)           drive A
    clr.l   -(sp)
    move.w  #buffer,-(sp)
    move.w  #10,-(sp)          flopfmt
    trap    #14
    add.l   #26,sp
    tst     d0
    bmi     error

buffer      ds.b    $2000     8K buffer
```

11 Unused

12 Midiws *write string to MIDI interface*

```
C: void Midiws(count, ptr)
   int  count;
   long ptr;
```

Assembler:

```
   move.l ptr,-(sp)
   move.w count,-(sp)
   move.w #12,-(sp)
   trap   #14
   addq.l #8,sp
```

With this function it is possible to output a string to the MIDI interface (MIDI OUT). The parameter `ptr` must point to a string, count must contain the number of characters to be sent minus 1.

Example:

```
   move.l #string,-(sp)                Address of the string
   move.w #stringend-string-1,-(sp)    Length
   move.w #12,-(sp)                    midiws
   trap   #14
   addq.l #8,sp

   ....

string    dc.b 'MIDI data"
stringend equ   *
```

13 Mfpint *initialize MFP format*

```
C: void Mfpint(number, vector)
   int  number;
   long vector;
```

Assembler:

```
    move.l vector,-(sp)
    move.w number,-(sp)
    move.w #13,-(sp)
    trap   #14
    addq.l #8,sp
```

This function initializes an interrupt routine in the MFP. The number of the MFP interrupt is in `number` while `vector` contains the address of the corresponding interrupt routine. The old interrupt vector is overwritten.

Example:

```
    move.l #busy,-(sp)        Busy interrupt routine
    move.w #0,-(sp)           Vector number 0
    move.w #13,-(sp)          mfpint
    trap   #14
    addq.l #8,sp
    ....
busy:
```

14 Iorec *return record buffer*

```
C: long Iorec(dev)
   int dev;
```

Assembler:

```
move.w dev,-(sp)
move.w #14,-(sp)
trap   #14
addq.l #4,sp
```

This function fetches a pointer to a buffer data record for an input device. The following input devices can be specified:

```
dev    Input device
 0     RS-232
 1     Keyboard
 2     MIDI
```

The buffer record for an input device has the following layout:

```
long  ibuf     Pointer to an input buffer
int   ibufsize Size of the input buffer
int   ibufhd   Head index
int   ibuftl   Tail index
int   ibuflow  Low water mark
int   ibufhi   High water mark
```

The input buffer is a circular buffer; the `head index` specifies the next write position (the buffer is filled by an interrupt routine) and the `tail index` specifies from where the buffer can be read. If the head and tail indices are the same, the buffer is empty. The low and high marks are used in connection with the communications status for the RS-232 (XON/XOFF or RTS/CTS). If the input buffer is filled up to the `high water mark`, the sender is informed via XON or CTS that the computer cannot receive any more data. When data received by the computer can be processed again, so that the buffer contents sink below the `low water mark`, the transfer is resumed.

There is an identically-constructed buffer record for the RS-232 output which is located directly behind the input record.

The following table contains the data for all devices:

	RS-232 input	RS-232 output	Keyboard	MIDI
Address	$9D0	($9DE)	$942	$A00
Buffer address	$6D0	$7D0	$8D0	$950
Buffer length	$100	$100	$80	$80
Head index	0	0	0	0
Tail index	0	0	0	0
Low water mark	$40	$40	$20	$20
High water mark	$C0	$C0	$20	$20

Head and tail indices are naturally dependent on the current operating mode. High and low water marks are set at 3/4 and 1/4 of the buffer size. They have significance only for XON/XOFF or RTS/CTS in connection with RS-232.

Example:

```
move.w #1,-(sp)     Buffer record for keyboard
move.w #14,-(sp)    iorec
trap   #14
addq.l #4,sp
...
```

Result: $9F2

15 Rsconf *set RS-232 configuration*

```
C: void Rsconf(baud, ctrl, ucr, rsr, tsr, scr)
   int baud, ctrl, ucr, rsr, tsr, scr;
```

Assembler:

```
move.w scr,-(sp)
move.w tsr,-(sp)
move.w rsr,-(sp)
move.w ucr,-(sp)
move.w ctrl,-(sp)
move.w baud,-(sp)
move.w #15,-(sp)
trap   #14
add.l  #14,sp
```

This XBIOS function serves to configure the RS-232 interface. The parameters have the following significance:

```
scr:  Synchronous Character Register in the MFP
tsr:  Transmitter Status Register in the MFP
rsr:  Receiver Status Register in the MFP
ucr:  USART Control Register in the MFP
ctrl: Communications parameters
baud: Baud rate
```

See the section on the MFP 68901 for information on the MFP registers. If one of the parameters is -1, the previous value is retained. The handshake mode can be selected with the `ctrl` parameter:

ctrl	Meaning
0	No handshake, default after power-up
1	XON/XOFF
2	RTS/CTS
3	XON/XOFF and RTS/CTS (not useful)

The `baud` parameter contains an indicator for the baud rate:

baud	baud rate
0	19200
1	9600
2	4800

```
baud  baud rate
  3     3600
  4     2400
  5     2000
  6     1800
  7     1200
  8      600
  9      300
 10      200
 11      150
 12      134
 13      110
 14       75
 15       50
```

Example:

```
move.w #-1,-(sp)
move.w #-1,-(sp)           Don't change MFP registers
move.w #-1,-(sp)
move.w #-1,-(sp)
move.w #1,-(sp)            XON/XOFF
move.w #9,-(sp)            300 baud
move.w #15,-(sp)           rsconf
trap   #14
add.l  #14,sp
```

16 Keytbl *set keyboard table*

```
C: long Keytbl(unshift, shift, capslock)
   long unshift, shift, capslock;
```

Assembler:

```
move.l capslock,-(sp)
move.l shift,-(sp)
move.l unshift,-(sp)
move.w #16,-(sp)
trap   #14
add.l #14,sp
```

With this function it is possible to create a new keyboard layout. To do this you must pass the address of the new tables which contain the key codes for normal keys (without shift), shifted keys, and keys with caps lock. The function returns the address of the vector table in which the three keyboard table pointers are located. If a table should remain unchanged, -1 must be passed as the address. A keyboard table must be 128 bytes long. It is addressed via the key scan code and returns the ASCII code of the given key.

Example:

```
   move.l #-1,-(sp)       Don't change caps lock
   move.l #shift,-(sp)    Shift table
   move.l #unshift,-(sp)  Table without shift
   move.w #16,-(sp)
   trap   #14
   addq.l #14,sp

   ....
shift:    ...
unshift:  ...
```

17 Random *return random number*

C: long Random()

Assembler:

```
move.w #17,-(sp)
trap   #14
addq.l #2,sp
```

This function returns a 24-bit random number. Bits 24-31 are zero. With each call you receive a different result. After turning on the computer a different seed is created.

Example:

```
move.w #17,-(sp)      random
trap   #14
addq.l #2,sp
```

---

18 Protobt *produce boot sector*

```
C: void Protobt(buffer, serialno,disktype, execflag)
   long buffer, serialno;
   int  disktype, execflag;
```

Assembler:

```
move.w execflag,-(sp)
move.w disktype,-(sp)
move.l serialno,-(sp)
move.l buffer,-(sp)
move.w #18,-(sp)
trap   #14
add.l  #14,sp
```

This function serves to create a boot sector. A boot sector is located on track 0, sector 1 on side 0 of a diskette and gives the DOS information about the disk type. If the boot sector is executable, it can be used to load the operating system. With this function you can create a new boot sector, for a different disk format or to change an existing boot sector.

The parameters:

`execflag`: determines if the boot sector is executable.

```
 0 not executable
 1 executable
-1 boot sector remains as it was
```

The disk type can assume the following values:

```
 0  40 track, single sided (180 K)
 1  40 track, double sided (360 K)
 2  80 track, single sided (360 K)
 3  80 track, double sided (720 K)
-1  Disk type remains unchanged
```

The parameter `serialno` is a 24-bit serial number which is written in the boot sector. If the serial number is greater than 24 bits ($01000000), a random serial number is created (with the above function). A value of -1 means that the serial number will not be changed.

The parameter `buffer` is the address of a 512-byte buffer which contains the boot sector or in which the boot sector will be created.

A boot sector has the following construction:

```
Address 40 track SS   40 track DS   80 track SS   80 track DS

  0- 1  Branch instruction to boot program if executable
  2- 7  'Loader'
  8-10  24-bit serial number
 11-12  BPS    512         512           512           512
 13     SPC      1           2             2             2
 14-15  RES      1           1             1             1
 16     FAT      2           2             2             2
 17-18  DIR     64         112           112           112
 19-20  SEC    360         720           720          1440
 21     MEDIA  252         253           248           249
 22-23  SPF      2           2             5             5
 24-25  SPT      9           9             9             9
 26-27  SIDE     1           2             1             2
 28-29  HID      0           0             0             0
510-511 CHECKSUM
```

BPS: Bytes per sector. The sector size is 512 bytes for all formats

SPC: Sectors per cluster. The number of sectors which are combined into one block by the DOS, 2 sectors equals 1K

RES: Number of reserved disk sectors,including the boot sector.

FAT: The number of file allocation tables on the disk.

DIR: The maximum number of directory entries.

SEC: The total number of sectors on the disk.

MEDIA: Media descriptor byte, not used by the ST-BIOS.

SPF: Number of sectors in each FAT.

SPT: Number of sectors per track.

SIDE: Number of sides of the diskette.

HID: Number of hidden sectors on the disk.

The boot sector is compatible with MS-DOS 2.x. This is why all 16-bit words are stored in 8086 format (first low byte, then high byte). If the checksum of the whole boot sector is $1234, the sector is executable. In this case the boot program is located at address 30.

This program adapts an existing boot sector for 80 tracks, double sided.

Example:

```
   move.w #-1,-(sp)       Don't change executability
   move.w #3,-(sp)        80 tracks DS
   move.l #-1,-(sp)       Don't change serial number
   move.l #buffer,-(sp)
   move.w #18,-(sp)       protobt
   trap   #14
   add.l  #14,sp

buffer ds.b 512
```

19 Flopver *verify diskette sector*

```
C: int Flopver(buffer,filler,dev,sector,track,side,count)
   long buffer, filler;
   int  dev, sector, track, side, count;
```

Assembler:

```
move.w count,-(sp)
move.w side,-(sp)
move.w track,-(sp)
move.w sector,-(sp)
move.w dev,-(sp)
clr.l  -(sp)
move.l buffer,-(sp)
move.w #19,-(sp)
trap   #14
add.l  #16,sp
```

This function verifies one or more sectors on the disk. The sectors are read from the disk and compared with the buffer contents in memory. The parameters are the same as for reading and writing sectors. If the sector and buffer contents agree, the result will be zero. If an error occurs, an error number will be returned in D0 (see **Read sector** for error codes). On an error, the buffer will contain a list of bad sectors (16-bit values) terminated by a zero word. If **Rwabs** was used to write the sectors and if *fverify* ($444) is set, the sectors will automatically be verified after they are written.

Example:

```
move.w #1,-(sp)         A sector
move.w #0,-(sp)         Side zero
move.w #39,-(sp)        Track 39
move.w #1,-(sp)         Sector 1
move.w #0,-(sp)         Drive A
clr.l  -(sp)
move.l #buffer,-(sp)    Buffer address
move.w #19,-(sp)        flopver
trap   #14
add.l  #16,sp
tst    d0               Error?
bmi    error
```

20 Scrdmp *output screen dump*

```
C: void Scrdmp()
```

Assembler:

```
move.w #20,-(sp)
trap   #14
addq.l #2,sp
```

This function sends a hardcopy of the screen to a connected printer. The previously-set printer parameters ("desktop Printer setup") are used. You can also perform this function by simultaneously pressing the ALT and HELP keys or from the desktop through "Print Screen" from the "Options" menu.

Example:

```
move.w #20,-(sp)      Hardcopy
trap   #14            Call XBIOS
addq.l #2,sp
```

---

21 Cursconf *set cursor configuration*

```
C: int Cursconf(function, rate)
   int function, rate;
```

Assembler:

```
move.w rate,-(sp)
move.w function,-(sp)
move.w #21,-(sp)
trap   #14
addq.l #6,sp
```

This XBIOS function serves to set the cursor function. The parameter `function` can have a value from 0-5, which have the following meanings:

```
function  meaning
    0     Disable cursor
    1     Enable cursor
```

```
function  meaning
    2     Flashing cursor
    3     Steady cursor
    4     Set cursor flash rate
    5     Get cursor flash rate
```

You can use this function to set whether the cursor is visible, and whether it is flashing or steady. The XBIOS function returns a result only if you fetch the old baud rate. The unit of the flash frequency is dependent on the screen frequency: It is 70 Hz for a monochrome monitor or 50 Hz for a color monitor. You can set a new flash rate with function number 5. You need only use the parameter `rate` if you want to pass a new flash rate.

Example:

```
move.w #20,-(sp)        20/70 seconds
move.w #4,-(sp)         Set flash rate
move.w #21,-(sp)        cursconf
trap   #14
addq.l #6,sp
```

---

22 Settime *set clock time and date*

```
C: void Settime(time)
   long time;
```

Assembler:

```
move.l time,-(sp)
move.w #22,-(sp)
trap   #14
add.l  #6,sp
```

This function is used to set the clock time and date. The time is passed in the lower word of `time` and the date in the upper word. The time and date are coded as follows:

```
bits  0- 4  Seconds in two-second increments
bits  5-10  Minutes
bits 11-15  Hours
bits 16-20  Day 1-31
```

```
bits 21-24   Month 1-12
bits 25-31   Year 0-119(minus offset 1980)
```

Example:

```
move.l #%1011001100000100000000000000,-(sp)
move.w #22,-(sp)      settime
trap   #14
addq.l #6,sp
```

This call sets the date to the 16th of September, 1985, and the clock time to 8 o'clock.

---

23 Gettime *return clock time and date*

`C: long Gettime()`

Assembler:

```
move.w #23,-(sp)
trap   #14
addq.l #2,sp
```

This function returns the current date and clock time in the following format:

```
bits  0- 4   Seconds in two-second increments
bits  5-10   Minutes
bits 11-15   Hours
bits 16-20   Day 1-31
bits 21-24   Month 1-12
bits 25-31   Year (minus offset 1980)
```

Example:

```
move.w #23,-(sp)     gettime
trap   #14
addq.l #2,sp
move.l d0,time       Save time and date
```

24 Bioskeys *restore keyboard table*

```
C: void Bioskeys()
```

Assembler:

```
move.w #24,-(sp)
trap   #14
addq.l #2,sp
```

If you have selected a new keyboard layout with the XBIOS function 16, *keytbl*, this function will restore the standard BIOS keyboard layout. You can call this function, for example, before exiting a program of your own which changed the keyboard layout.

Example:

```
move.w #24,-(sp)    bioskeys
trap   #14
addq.l #2,sp
```

25 Ikbdws *intelligent keyboard send*

```
C: void Ikbdws(number, pointer)
   int  number;
   long pointer;
```

Assembler:

```
move.l pointer,-(sp)
move.w number,-(sp)
move.w #25,-(sp)
trap   #14
addq.l #8,sp
```

This XBIOS function serves to transmit commands to the keyboard processor (intelligent keyboard). The parameter `pointer` is the address of a string to be sent, `number` is the length of a string minus 1.

Example:

```
    move.l #string,-(sp)            Address of the string
    move.w #strend-string-1,-(sp)   Length minus 1
    move.w #25,-(sp)                ikbdws
    trap   #14
    addq.l #8,sp
    ...
string     dc.b   $80,1
strend     equ    *
```

26 Jdisint

disable interrupts on MFP

```
C: void Jdisint(number)
   int number;
```

Assembler:

```
    move.w number,-(sp)
    move.w #26,-(sp)
    trap   #14
    addq.l #4,sp
```

This function makes it possible to selectively disable interrupts on the MFP 68901. The parameter is the MFP interrupt number (0-15). The significance of the individual interrupts is described in the section on interrupts.

Example:

```
    move.w #10,-(sp)    Disable RS-232 transmitter interrupt
    move.w #26,-(sp)    Disable interrupt
    trap   #14
    addq.l #4,sp
```

27 Jenabint *enable interrupts on MFP*

```
C: void Jenabint(number)
   int number;
```

Assembler:

```
move.w number,-(sp)
move.w #27,-(sp)
trap   #14
addq.l #4,sp
```

This function can be used to re-enable an interrupt on the MFP. The parameter is again the number of the interrupt, 0-15.

Example:

```
move.w #12,-(sp)      Enable RS-232 receiver interrupt
move.w #27,-(sp)      Enable interrupt
trap   #14
addq.l #4,sp
```

28 Giaccess *access GI sound chip*

```
C: char Giaccess(data, register)
   char data;
   int  register;
```

Assembler:

```
move.w #register,-(sp)
move.w #data,-(sp)
move.w #28,-(sp)
trap   #14
addq.l #6,sp
```

This function allows access to the GI sound chip registers. `register` must contain the register number of the sound chip (0-15). The meaning of the individual registers is given in the hardware description of the sound chip.

Bit 7 of the register number determines whether the specified register will be written or read:

```
Bit 7  0: Read
       1: Write
```

When writing, an 8-bit value is passed in `data;` when reading, the function returns the contents of the corresponding register.

Example:

```
move.w #$80+3,-(sp)      Write register 3
move.w #$50,-(sp)        Value to write
move.w #28,-(sp)
trap   #14
addq.l #6,sp
```

29 Offgibit *reset Port A GI sound chip*

```
C: void Offgibit(bitnumber)
   int bitnumber;
```

Assembler:

```
move.w #bitnumber,-(sp)
move.w #29,-(sp)
trap   #14
addq.l #4,sp
```

A bit of port A of the sound chip can be selectively set with this function call. Port A is an 8-bit output port in which the individual bits have the following function:

```
Bit 0:  Select disk side 0/side 1
Bit 1:  Select drive A
Bit 2:  Select drive B
Bit 3:  RS-232 RTS (Request To Send)
Bit 4:  RS-232 DTR (Data Terminal Ready)
Bit 5:  Centronics strobe
Bit 6:  General Purpose Output
Bit 7:  unused
```

Example:

```
move.w #4,-(sp)      DTR bit
move.w #29,-(sp)     offgibit
trap   #14
addq.l #4,sp
```

30 Ongibit *clear Port A of GI sound chip*

```
C: void ongibit(bitnumber)
   int bitnumber;
```

Assembler:

```
move.w #bitnumber,-(sp)
move.w #30,-(sp)
trap   #14
addq.l #4,sp
```

This function is the counterpart of the previous function. With this it is possible to clear a bit of port A in the sound chip.

Example:

```
move.w #4,-(sp)      DTR bit
move.w #30,-(sp)     ongibit
trap   #14
addq.l #4,sp
```

31 Xbtimer *start MFP timer*

```
C: void Xbtimer(timer, control, data, vector)
   int  timer, control, data;
   long vector;
```

Assembler:

```
   move.l vector,-(sp)
   move.w data,-(sp)
   move.w control,-(sp)
   move.w timer,-(sp)
   move.w #31,-(sp)
   trap   #14
   add.l  #12,sp
```

This function allows you to start a timer in the MFP 68901 and assign an interrupt routine to it. `timer` is the number of the timer in the MFP:

```
Timer A : 0 /  Timer B : 1 /  Timer C : 2 /  Timer D : 3
```

The parameters `data` and `control` are the values placed in the control and data registers of the timer (see the hardware description of the MFP 68901).

The parameter `vector` is the address of the interrupt routine which will be executed when the timer runs out. The four timers in the MFP are already partly used by the operating system:

```
Timer A: Reserved for the end user
Timer B: Horizontal blank counter
Timer C: 200 Hz system timer
Timer D: RS-232 baud rate generator (interrupt vector free)
```

Example:

```
   move.l #vector,-(sp)     Interrupt routine
   move.w data,-(sp)        Data and
   move.w control,-(sp)     Control registers
   move.w #0,-(sp)          Timer A
   move.w #31,-(sp)         xbtimer
   trap   #14
   add.l  #12,sp
```

32 Dosound *set sound parameters*

```
C: void Dosound(pointer)
   long pointer;
```

Assembler:

```
move.l pointer,-(sp)
move.w #32,-(sp)
trap   #14
addq.l #6,sp
```

This function allows for easy sound processing. The parameter `pointer` must point to a string of sound commands. The following commands can be used:

Commands $00-$0F
: These commands are interpreted as register numbers of the sound chip. A byte following this is loaded into the corresponding register.

Command $80
: An argument follows this command which will be loaded into a temporary register.

Command $81
: Three arguments must follow this command. The first argument is the number of the sound chip register in which the contents of the temporary register will be loaded. The second argument is a two's-complement value which will be added to the temporary register. The third argument contains an end criterion. The end is reached when the content of the temporary register is equal to the end criterion.

Commands $82-$FF
: One argument follows each of these commands. If this argument is zero, the sound processing is halted. Otherwise this argument specifies the number of timer ticks (20ms, 50Hz) until the next sound processing.

Example:

```
move.l #pointer,-(sp)     Pointer to sound command
move.w #32,-(sp)          dosound
```

```
   trap    #14
   addq.l #6,sp
   ....
pointer   dc.b 0,10,1,50,...
```

33 Setprt *set printer configuration*

```
C: void Setprt(config)
   int config;
```

Assembler:

```
   move.w config,-(sp)
   move.w #33,-(sp)
   trap    #14
   addq.l #4,sp
```

This function allows the printer configuration to be read or changed. If `config` contains the value -1, the current value is returned, otherwise the value is accepted as the new printer configuration. The printer configuration is a bit vector with the following meaning:

Bit number	0	1
0	matrix printer	daisy-wheel
1	monochrome printer	color printer
2	Atari printer	Epson printer
3	Test mode	Quality mode
4	Centronics port	RS-232 port
5	Continuous paper	Single-sheet
6-14	reserved	
15	always 0	

Example:

```
   move.w #%000100,-(sp)    Epson printer
   move.w #33,-(sp)         setprt
   trap    #14
   addq.l #4,sp
```

34 Kbdvbase *return keyboard vector table*

C: `long Kbdvbase()`

Assembler:

```
move.w #34,-(sp)
trap   #14
addq.l #2,sp
```

This XBIOS function returns a pointer to a vector table which contains the address of routines which process the data from the keyboard processor. The table is constructed as follows:

```
long  midivec     MIDI input
long  vkbderr     Keyboard error
long  vmiderr     MIDI error
long  statvec     IKBD status
long  mousevec    Mouse routines
long  clockvec    Clock time routine
long  joyvec      Joystick routines
long  midisys     MIDI system vector
long  ikbdsys     IKBD system vector
```

The parameter `midivec` points to a routine which writes data received from the MIDI input (byte in D0) to the MIDI buffer.

The parameters `vkbderr` and `vmiderr` are called when an overflow is signaled by the keyboard or MIDI ACIA.

The routines `statvec`, `mousevec`, `clockvec`, and `joyvec` process the data packages which come from the keyboard ACIA. A pointer to the packages received is passed to these routines in D0. The mouse vector is used by GEM. If you want to use your own routine, you must terminate it with RTS and processing time may take no longer than one millisecond.

The remaining routines `midisys and ikbdsys` are called when there is a character in the present ACIA. `midisys` holds the character and jumps to `midivec`; `ikbdsys` gets the data package from the ACIA, and branches to the abovementioned routines.

Example:

```
move.w #34,-(sp)     kbdvbase
trap   #14
addq.l #2,sp
```

We get $DCC as the result. The vector field contains the following values:

```
midivec    $FC2CE2/$8B70
vkbderr    $FC288E/$871C    (RTS)
vmiderr    $FC288E/$871C    (RTS)
statvec    $FC230A/$8198    (RTS)
mousevec   $FD02C2/$16150
clockvec   $FC1D12/$7BA0
joyvec     $FC230A/$8198    (RTS)
midisys    $FC284A/$86D8
ikbdsys    $FC285A/$86E8
```

35 Kbrate *set keyboard repeat rate*

```
C: int Kbrate(delay, repeat)
   int delay, repeat;
```

Assembler:

```
move.w repeat,-(sp)
move.w delay,-(sp)
move.w #35,-(sp)
trap   #14
addq.l #6,sp
```

The keyboard repeat can be controlled with this function. The parameter `delay` specifies the delay time after a key is pressed before the key will automatically be repeated. The parameter `repeat` determines the time span after which the key will be repeated again. These values can be changed from the desktop by means of the two slide controllers on the control panel. The times are based on the 50 Hz system clock. If -1 is specified for one of the parameters, the corresponding value is not set. The function returns the previous values as the result; bits 0-7 contain the `repeat` value and bits 8-15 the value of `delay`.

Example:

```
move.w #-1,-(sp)      Read old values
move.w #-1,-(sp)
move.w #35,-(sp)      kbrate
trap   #14
addq.l #6,sp
```

Result: D0 = $0B03

36 Prtblk *output block to printer*

```
C: void Prtblk(parameter)
   long parameter;
```

Assembler:

```
move.l parameter,-(sp)
move.w #36,-(sp)
trap   #14
addq.l #6,sp
```

This function resembles and is used by the function **Scrdmp** (20). The function expects a parameter list, however, whose address is passed to it. This list is constructed as follows:

```
long  blkprt   Address of the screen RAM
int   offset
int   width    Screen width
int   height   Screen height
int   left
int   right
int   scrres   Screen resolution (0, 1, or 2)
int   dstres   Printer resolution (0 or 1)
long  colpal   Address of the color palette
int   type     Printer type (0-3)
int   port     Printer port (0=Centronics, 1=RS-232)
long  masks    Pointer to half-tone mask
```

Example:

```
    move.l #parameter,-(sp)   Address of the parameter block
    move.w #36,-(sp)          prtblk
    trap   #14
    addq.l #6,sp
    ...
parameter dc.l ...
```

37 Vsync *wait for video*

`C: void Vsync()`

Assembler:

```
    move.w #37,-(sp)
    trap   #14
    addq.l #2,sp
```

This function waits for the next picture return. It can be used to synchronize graphic outputs with the beam return, for example.

Example:

```
    move.w #37,-(sp)      wait for vsync
    trap   #14
    addq.l #2,sp
```

38 Supexec *set supervisor execution*

```
C: void Supexec(address)
   long address;
```

Assembler:

```
move.l address,-(sp)
move.w #38,-(sp)
trap   #14
addq.l #6,sp
```

A routine can be executed in supervisor mode with **Supexec**.

Example:

```
  move.l #address,-(sp)
  move.w #38,-(sp)
  trap   #14
  addq.l #6,sp
  ...
address   move.l $400,00
```

39 Puntaes *disable AES*

```
C: void Puntaes()
```

Assembler:

```
move.w #39,-(sp)
trap   #14
addq.l #2,sp
```

The AES can be disabled with this function, provided it is not in ROM.

Example:

```
move.w #39,-(sp)
trap   #14
addq.l #2,sp
```

64 Blitmode *read and alter blitter*

```
C: int Blitmode(flag)
   int flag;
```

Assembler:

```
    move.w  flag,-(sp)
    move.w  #64,-(sp)
    trap #14
    addq.l  #4,sp
```

This function lets you read and change an available blitter's configuration. **Blitmode** also lets you determine whether a blitter exists in the system (bit 1) and whether it is usable (bit 0). The ST reads the current configuration when `flag` has a value of -1 (0xffff). The result is a bitmask. Each bit represents the following:

Bit number	0	1
0	Blit-operation through software	Blit_operation through hardware
1	No blitter available	Blitter available
2-14	Undefined, reserved	
15	Always 0	

When a blitter is available, you can determine whether blit operations can be performed by software or by the blitter. This is established by clearing or setting bit 0.

Bit number	0	1
0	Blit-operation through software	Blit_operation through hardware
1-14	Undefined, reserved	
15	Always 0	

Example:

```
    move    #-1,(sp)    set configuration
    move    #64, -(sp)  blitmode
    trap    #14
    addq.l  #4,sp
    btst    #1,d0       is blitter on hand?
    beq     no_blit     no
```

```
bset   #0,d0
move   d0,-(sp)      blit operation through hardware
move   #64, -(sp)    blit-mode
trap   #14
addq.l #4, sp
no_blit:
rts
```

The above sample program tests for an onboard blitter. If this is the case, the system bit 0 displays blit operations through hardware (the blitter). The test, once set to hardware, won't ignore onboard blitters in the system.

By setting the blit mode, this should call the configuration, and the bits 1-14 should be taken over. They are reserved for further graphic functions or graphic chips.

3.4 The Graphics

Next to the high processing speed and the large memory available, the graphics capability is certainly the most fascinating aspect of the ST. With the standard monochrome monitor and the resolution of 640x400 points, it creates a whole new price/performance class for itself. But also in the color resolution the ST can display 16 colors with 320x200 screen points.

In this chapter we want to explain how the graphics are organized and how you can create fast and effective graphics without using the GEM graphics package, which is rather complicated for beginners. The ST offers the assembler and C programmer very useful routines which don't exactly make graphics programming child's play, but which can take away a good deal of the programming work. Unfortunately, some of these functions are so comprehensive that a detailed description would exceed the scope of this book. We have therefore had to limit ourselves to the simpler, but no less interesting functions.

These graphics routines are called in a very elegant manner. The software developers have made use of the fact that there are two groups of opcodes in the 68000 which the 68000 does not "understand" and which generate a trap, or software interrupt, when they are encountered in a program. These are the two groups of opcodes which begin with $Axxx and $Fxxx. In the ST, the $Axxx opcode trap is used in order to access the graphics routines. The trap handler, the program called by the trap, checks the lowest byte of the "command" to see what value it has. Values between zero and $F are permissible here. This gives a total of 16 graphics routines, which should first be presented in an overview. Later we will talk about the actual commands in detail.

```
$A000  Determine address of required variable range
$A001  Set point on the screen
$A002  Determine color of a screen point
$A003  Draw a line on the screen
$A004  Draw a horizontal line (very fast!)
$A005  Fill rectangle with color
$A006  Fill polygon line by line
$A007  Bit block transfer
$A008  Text block transfer
$A009  Enable mouse cursor
$A00A  Disable mouse cursor
```

```
$A00B Change mouse cursor form
$A00C Clear sprite
$A00D Enable sprite
$A00E Copy raster form
$A00F Contour fill (Flood fill)
```

These routines are the ground work for the hardware-dependent part of GEM. All GEM graphic and text output is performed by the routines of the $Axxx opcodes. The set of A-opcodes are very useful in games. In games windows are needed only in the rarest cases. Another important point is the speed of the line A-instructions. Using the graphic routines directly is clearly faster than if the output is handled by GEM. Before we describe the individual commands in detail, we will take a brief look at the construction of graphics in the various graphic modes of the ST.

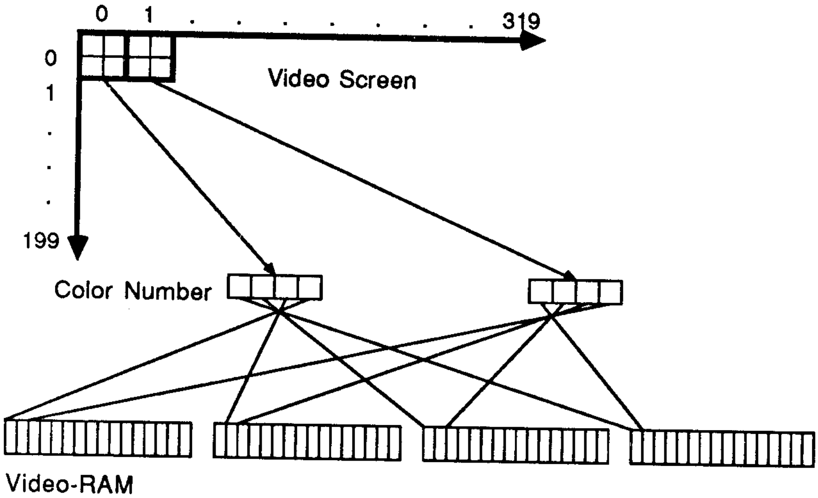
Immediately after turning the ST on, an area of 32K bytes is initialized at the upper memory border as the video RAM. In normal operation this results in addresses $78000 to $7FFFF or $F8000 to $FFFFF acting as the screen RAM. This video RAM can be viewed as a window in the ST. The following description is a simplification of the features of the 260ST with "only" 512K.

We will start with the simplest mode, the 640x400 mode. In this case each set of 80 bytes, or better, each set of 40 words forms one screen line. The word with the lowest address is displayed on the left edge of the screen, the additional words are displayed in order from left to right. Within a word, the highest-order bit lies at the left and the lowest-order bit at the right.

With this data, any point on the screen can be easily controlled or read. For example, to set the first screen point, the value $8000 must be written into memory location $78000. There is one small limitation to this area. The position of ST screen RAM can be easily moved. For this reason, it is usually more advantageous to set the point with the "A" function $A001. Function $A001 assumes an X-Y coordinate system with origin in the upper left-hand corner, and determines the position of the video RAM itself in order to set the point at the proper screen location.

In this resolution mode, each screen point is represented by a bit. If the bit is set, the point appears dark, or bright if the inverse display mode is selected in color palette register 0. The screen consists of only one bit plane. Different colors cannot be represented with just one plane, however. This is why when the resolution increases in the color modes, the number of displayable colors decreases.

Figure 3.4-1 LO-RES-MODE (0)



Four colors are possible in the 640x200 resolution mode. In this mode, two contiguous memory words form a single logical entity. The color of a point is determined by the value of the two corresponding bits in the two words. If both bits are zero, the background color results. Therefore two sequential words are used together for pixel representation. For the colors, however, all odd words belong to a plane. The second plane is made up of the even words. In this mode, there are two planes available.

Things become quite colorful in the mode with "only" 320x200 points. In this operating mode, 4 contiguous memory words form one entity which determines the color of the 16 pixels. To stick to the example we used before: in order to set the point in the upper left-hand corner, the topmost bits of words $78000, $78002, $78004, and $78006 must be manipulated. The desired color results from the bit pattern in the words.

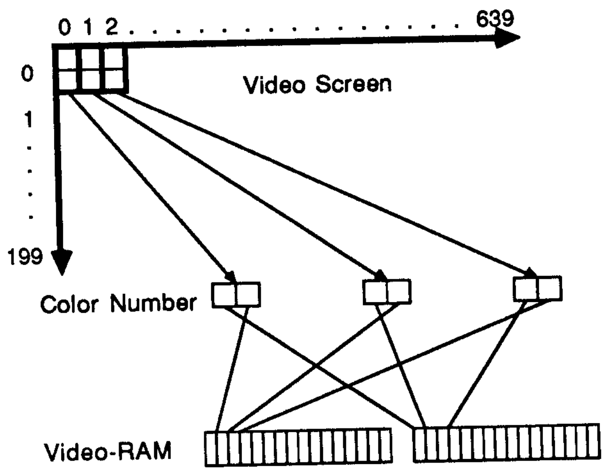
It naturally requires some computer time to set a point in the desired color, independent of the mode. All of this work is handled by the $A001 routine, however. This routine sets all of the pertaining bits for the desired color in the current resolution. Naturally, all four planes are present in this mode. The first plane, keeping to our example, made up of the words at address $7F000, $7F008, $7F010, ..., and the other planes are composed of the other addresses correspondingly.

Another point to be clarified concerns the fonts or character sets. Since the ST does not have a text mode, only a graphics mode, the text output is created in high-resolution graphics. There are three different fonts built into

the ST. You can load additional fonts from disk. Each font has a header which contains important information about the displayable characters. Since the important data are contained in the font header, there are unusually few limits for display. The characters can be arbitrarily high or wide. The age of the 8x8 matrix for character output is over. It is even possible to get cursive, bold, true proportional or other type on the screen.

The three built-in fonts are monospaced fonts, meaning they have a fixed defined size in pixels and a defined pitch. The smallest font has a matrix of 6x6. With a resolution of 640x400 points, 66 lines of 106 characters each can be displayed. This font is only accessible for output under GEM, not for output under TOS, and is used in the output of the directory in the icon form, for example. The next-largest type is composed of 8x8 points. This type is used when a color monitor is connected to the ST, while the third and largest font is used for the normal black-and-white mode. This font uses a matrix of 8x16 points.

Figure 3.4-2 MEDIUM-RES-MODE (1)



The exact layout of the font header is found under command $A008, which represents a very versatile text output which goes far beyond what is possible with the routine of the BIOS and GEMDOS.

Finally, we must clarify some of the terms which will come up often in the following descriptions, whose meanings may not be so clear. These are the terms Contrl array, Intin array, Intout array, Ptsin array and Ptsout array.

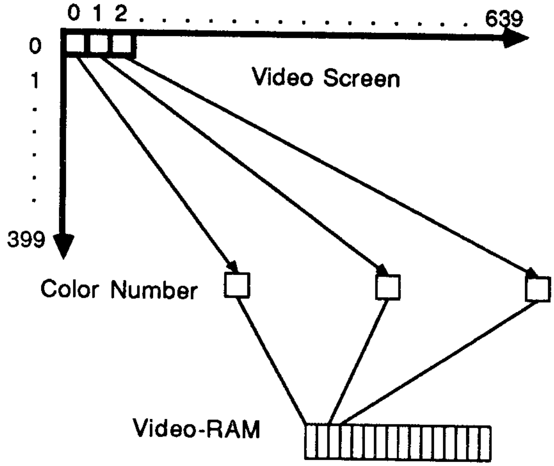
These arrays are mainly used by GEM to pass parameters to individual GEM functions or to store results from these functions. But line-A functions use parts of these arrays to pass parameters also. The arrays are defined in memory as data areas, whereby each element in the array consists of 2 bytes.

For GEM functions, the Contrl array always contains the number desired in the first element (Contrl(0)). This parameter is not used by the line-A commands, however. Contrl(1) contains the number of XY coordinates required for the function. These coordinates must be placed in the Ptsin array before the call. The element Contrl(2) is not supplied before the call. After the call it contains the number of XY coordinates in the Ptsout array. Contrl(3) specifies how many parameters will be passed to the function in the Intin array, while Contrl(4) contains the number of parameters in the Intout array after the call. The additional parameters of the Contrl array are not relevant for users of the line A.

Unfortunately, not all of the A opcode parameters can be in these arrays. For this reason there is another memory area which used as a variable area for (almost) all graphic outputs. The functions and uses of these over 50 variables are in a table at the end of this chapter. Important variables are also explained in conjunction with the functions requiring them.

By the way, you should be aware that registers D0 to D2 and A0 to A2 are changed by calling the functions. Important values contained in these registers should be saved before a call.

Figure 3.4-3 HI-RES-MODE (2)



$A000 Initialize

Initialize is really the wrong expression for this function. After the call, the addresses of the more important data areas are returned in registers D0 and A0 to A2. This function does not require input parameters.

The program is informed of the starting address of the line-A variables in D0 and A0. After the call, A1 points to a table with three addresses. These three addresses are the starting address of the three system font headers. Register A2 points to a table with the starting addresses of the 16 line-A routines.

This opcode destroys (at least) the contents of registers D0 to D2 and A0 to A2. Important values should be saved before the call.

$A001 PUT PIXEL

This opcode sets a point at the coordinates specified by the coordinates in `Ptsin(0)` and `Ptsin(1)`. The color is passed in `Intin(0)`. `Ptsin(0)` contains X-coordinate, `Ptsin(1)` the Y-coordinate.

The coordinate system used has its origin in the upper left corner. The possible range of the X and Y coordinates is naturally set according to the graphic mode enabled. Overflows in the X range are not handled as errors. Instead, the Y coordinate is simply incremented by the appropriate amount. No output is made if the Y range is exceeded.

The color in `Intin(0)` is dependent on the mode used. When driving the monochrome monitor, only bit zero of the value of `Intin(0)` is evaluated.

$A002 GET PIXEL

The color of a pixel can be determined with this opcode. As with $A001, the XY coordinates are passed in `Ptsin(0)` and `Ptsin(1)`; the color value is returned in the D0 register.

$A003 LINE

With the LINE opcode a line can be drawn between the points with coordinates x1,y1 and x2,y2. The parameters for this function are not passed via the parameter arrays, but must be transferred to the line-A variables before the call. The variables used are:

```
_X1      = x1 coordinate
_Y1      = y1 coordinate
_X2      = x2 coordinate
_Y2      = y1 coordinate
_FG_BP_1 = Plane 1 (all three modes)
_FG_BP_2 = Plane 2 (640x200, 320x200)
_FG_BP_3 = Plane 3 (only 320x200)
_FG_BP_4 = Plane 4 (only 320x200)
_LN_MASK = Bit pattern of the line
           For example: $FFFF = filled
                        $CCCC = broken
_WRT_MOD = Determines the write mode
_LSTLIN  = This variable should be set to -1 ($FFFF)
```

One point to be noted for some applications is the fact that when drawing a line, the highest bit of the line bit pattern is always set on the left screen edge. The line is always drawn from left to right and from top to bottom, not from x1,y1 to x2,y2.

Range overflows are handled as for PUT PIXEL. If an attempt is made to draw a line from 0,0 to 650,50, a line is actually drawn from, 0,0 to 639,48. The "remainder" results in an additional line from 0,49 to 10,50.

A total of four different write modes, with values 0 to 3, are available for drawing lines. With write mode zero, the original bit pattern "under" the line is erased and the bit pattern determined by `_LN_MASK` is put in its place (replace mode). In the transparent mode (`_WRT_MOD=1`), the background, the old bit pattern, is ORed with the new line pattern so only additional points are set. In the XOR mode (`_WRT_MOD=2`), the background and the line pattern are exclusive-ored. The last mode (`_WRT_MOD=3`) is the so-called "inverse transparent mode." As in the transparent mode, it involves an OR combination of the foreground and background data, in which the foreground data, the bit pattern determined by `_LN_MASK`, are inverted before the OR operation.

$A004 HORIZONTAL LINE

This function draws a line from x1,y1 to x2,y1. Drawing a horizontal line is significantly faster than when a line must be drawn diagonally. Diagonal lines are also created with this function, in which the line is divided into multiple horizontal lines segments. The parameters are entered directly into the required variables.

```
_X1       = x1 coordinate
_Y1       = y1 coordinate
_X2       = x2 coordinate
_FG_BP_1  = Plane 1 (all three modes)
_FG_BP_2  = Plane 2 (640x200, 320x200)
_FG_BP_3  = Plane 3 (only 320x200)
_FG_BP_4  = Plane 4 (only 320x200)
_WRT_MOD  = Determines the write mode
_patptr   = Pointer to the line pattern to use
_patmsk   = "Mask" for the line pattern
```

The valid values in `_WRT_MOD` also lie between 0 and 3 for this call. The contents of the variable `_patptr` is the address at which the desired line pattern or fill pattern is located. The H-line function is very well-suited to creating filled surfaces. The variable `_patmsk` plays an important role in this. The number of 16-bit values at the address in `_patptr` is dependent on the its value. If, for example, `_patmsk` contains the value 5, six 16-bit values should be located at the address in `_patptr` as the line pattern. If a horizontal line with the Y-coordinate value zero is to be drawn, the first bit pattern is taken as the line pattern. The second word is taken as the pattern for a line drawn at Y-coordinate 1, and so on. The pattern for a line with Y-coordinate 6 is again determined by the first value in the bit table. In this manner, very complex fill patterns can be created with relatively little effort.

$A005 FILLED RECTANGLE

The opcode $A005 represents an extension, or more exactly a special use, of opcode $A004. It is used to created filled rectangles. The essential parameters are the coordinates of the upper left and lower right corners of the of the rectangle.

```
_X1       = x1 coordinate, left upper
_Y1       = y1 coordinate
_X2       = x2 coordinate, right lower
```

```
_Y2        = y2 coordinate
_FG_BP_1   = Plane 1 (all three modes)
_FG_BP_2   = Plane 2 (640x200, 320x200)
_FG_BP_3   = Plane 3 (only 320x200)
_FG_BP_3   = Plane 4 (only 320x200)
_WRT_MOD   = Determines the write mode
_patptr    = Pointer to the fill pattern used
_patmsk    = "Mask" for the fill pattern
_CLIP      = Clipping flag
_XMN_CLIP  = X minimum for clipping
_XMX_CLIP  = X maximum for clipping
_YMN_CLIP  = Y minimum for clipping
_YMX_CLIP  = Y maximum for clipping
```

We have already explained all of the variables except the "clipping" variables. What is clipping? Clipping creates extracts or clippings of the total picture. If the clipping flag is set to one (or any value not equal to zero), the rectangle, drawn by $A005, is displayed only in the area defined by the clipping-area variables. An example may explain this behavior better: The values 100,100 and 200,200 are specified as the coordinates. The clip flag is 1 and the clip variables contain the values 150,150 for `XMN_CLIP` and `YMN_CLIP` as well as 300,300 for `XMX_CLIP` and `YMX_CLIP`. The value $FFFF will be chosen as the fill value for all of the lines. With these values, the rectangle will have the coordinate 150,150 as the upper left corner and 200,200 as the lower right. The "missing" area is not drawn because of the clip specifications. Clearing the clip flag draws the rectangle in the originally desired size.

$A006 FILLED POLYGON

$A006 is also an extension of $A004. Areas can be filled with a pattern with this function. The entire surface is not filled with the call: just one raster line is filled, a horizontal line with a width of one point. The result is that there are significantly more options for influencing the fill pattern.

The necessary variables are:

```
Ptsin       = Array with the XY coordinates
Contrl(1)   = Number of coordinate pairs
_Y1         = y1 coordinate
_FG_BP_1    = Plane 1 (all three modes)
_FG_BP_2    = Plane 2 (640x200, 320x200)
```

```
_FG_BP_3   = Plane 3 (only 320x200)
_FG_BP_3   = Plane 4 (only 320x200)
_WRT_MOD   = Determines the write mode
_patptr    = Pointer to the fill pattern used
_patmsk    = "Mask" for the fill pattern
_CLIP      = Clipping flag
_XMN_CLIP  = X minimum for clipping
_XMX_CLIP  = X maximum for clipping
_YMN_CLIP  = Y minimum for clipping
_YMX_CLIP  = Y maximum for clipping
```

Basically, all of the parameters here are to be set exactly as they might be for a call to $A005. Only the first three coordinates are different. The XY coordinates are stored in the `Ptsin` array. It is important you specify the start coordinate again as the last coordinate as well. In order to fill a triangle, you must, for example, enter the coordinates (320,100), (120,300), (520,300), and (320,100). The number of effective coordinate pairs, three in our example, must be placed in `Contrl(1)`, the second element of the array. With a call to the $A006 function you must also specify the Y-coordinate of the line to be drawn. Naturally you can fill all Y-coordinates from 0 to 399 (0 to 199 in the color modes) in order. But it is faster to find the largest and smallest of the XY values and call the function with only these as the range.

$A007 BITBLT

The BITBLock Transfer function copies a square source range into a target area. The source range can combine with a raster. Source and target range can be combined with 16 different logical operations. You can have these at any address. Normally it is at least the target area of video RAM; but it can also be copied within the screen or from an unused part of memory to another. If a blitter is onboard the ST, BITBLT uses hardware.

BITBLT is used by the line-A functions TEXTBLT and COPY RASTER FORM, as well as the VDI functions Copy Raster Opaque (vro_cpyfm) and Copy Raster Transparent (vrt_cpyfm). BITBLT's versatility involves the parameters used with the function call. These parameters are source, destination and pattern; information about the number of bitplanes (color or b/w) used; and logical operations combining source and destination. The data stands in a 76-byte parameter block, whose function address must be given through register A6. The parameter block looks like this:

Offset	Length	Name	
0	W	s_width	Pixel width of range being edited
2	W	2_height	Pixel height of range being edited
4	W	planes	Number of bit planes
6	W	fg-col	Foreground color
8	W	bg_col	Background color
10	L	op_tab	Logical operation
14	W	s_xmin	Source upper left X-coordinate
16	W	s_ymin	Source upper left Y-coordinate
18	L	s_form	Source starting address
22	W	s_nxwd	Byte offset of next source line
24	W	s_nxln	Byte offset of next source line
26	W	s_nxpl	Byte offset of next source color plane
28	W	d_xmin	Destination upper left X-coordinate
30	W	d_ymin	Destination upper left Y-coordinate
32	L	d_form	Start address through destination
36	W	d_nxwd	Byte offset of next destination word
38	W	d_nxln	Byte offset of next destination line
40	W	d_nxpl	Next destination color plane
42	L	p_addr	Start address of pattern
46	W	p_nxln	Byte offset of next raster line
48	W	p_nxpl	Byte offset of next color plane
50	W	p_mask	Raster height (raster index mask)
52	12W	filler	Used internally by BITBLT

When destination and/or source ranges appear on the screen, the following values are used:

Resolution	320*200	640*200	640*400
Bitplanes	4	2	1
d_form/s_form		screen address	
d_nxwd/s_nxwd	8	4	2
d_nxln/s_nxln	160	160	80
d_nxpl/s_nxpl	2	2	2

Here are the 16 logical operations used in combining source and desination:

Operation	Function	
0	D' = 0	Set destination to background color
1	D' = S &D	
2	D'= S & ~D	
3	D' = S	Replace Mode

```
 4      D' = ~S & D    Erase Mode
 5      D' = D
 6      D' = S ^ D     XOR Mode
 7      D' = S | D
 8      D' = ~ (S | D)
 9      D' = ~ (S ^ D)
10      D' = ~D
11      D' = S | ~D
12      D' = ~S
13      D' = ~S | D
14      D' = ~(S & D)
15      D' = 1          Set destination to foreground color
```

S=Source; D=Destination range before operation; D'=Destination range after the operation; &=logical AND; |=logical OR; ^=XOR (exclusive OR); ~=inversion.

Four such logical operations are given for BITBLT, addressed in the equation op = 2 * fg + bg. op is the used logical operation (0-3, relative to op_tab). fg is the foreground color and bg is the background color.

$A008 TEXTBLT

A character from any desired text font can be printed at any graphic position with the TEXT BLock Transfer function. In addition, the form of the character can be changed. The character can be displayed in italics, boldface, outlines, enlarged, or rotated. These things cannot be achieved with the "normal" character outputs via the BIOS or GEMDOS. TXTBLT often stands as the basic structure of all text output under VDI (v_gtext,etc.).

For the correct use of this function, a large number of parameters must be set and controlled. A rather complicated program must be written in order to output text with this function. If the additional options are not absolutely necessary, it is advisable not to use this function. But decide for yourself.

Before we produce a character on the screen, we must first concern ourselves with the organization of the fonts. We must take an especially close look at the font header because the font is described in detail by the information contained in it.

A font basically consists of four sets of data: font header, font data, character offset table and horizontal offset table. The font header contains general data about the font, such as its name and size, the number of characters it contains, and various other aspects. This information takes up a total of 88 bytes. The font data contains the bit pattern of the existing displayable characters. These data are organized to save as much space as possible.

In order to be able to better describe the organization, we will imagine a font with only two characters, such as "A" and "B". These characters are to be displayed in a 9x9 matrix. The font data are now in memory so that the bit pattern of the top scan line of the "A" is stored starting at a word boundary.

Since our font is 9 pixels = 9 bits wide, one byte is completely used, but only the top bit of the following byte. 7 bits must be wasted if the top scan line of the "B" is also to begin on a word boundary. This is not so, however, and the first scan line of the "B" starts with bit 6 of the second byte of the font data. Only the data of the second and further scan lines always start on a word boundary. In this manner, almost no bits are wasted in the font. Only the start of the scan lines of the first character actually begin on a word boundary; all other scan lines can begin at any bit position.

Because of this space-saving storage, the position of each character within the font must be calculated. The calculation of the scan-line positions is possible through the character offset table. This table contains one entry for each displayable character. For our example, such a table would contain the entries $0000, $0009, $0012. Through the direction of this table, it is possible to create true proportional type on the screen since the width of each character can be calculated. One subtracts the entry of the character to be displayed from the entry of the next character. The last entry is present so that the width of the last character can also be determined, although it is not assigned to a character.

In addition to the character offset table there is the horizontal offset table. This table is not used by most of the fonts, however. The fonts present in the ST do not use all the possibilities of this table either. If this table were present, it would contain a positive or negative offset value for each character, in order to shift the character to the right or left during output.

At the end of the description of the font construction are the meanings of the variables in the font header.

Bytes	0- 1	: Font identifier. A number which describes the font. 1=system font
Bytes	2- 3	: Font size in points (point is a measure used in typesetting).
Bytes	4-35	: The name of the font as an ASCII string.
Bytes	36-37	: Lowest ASCII value of displayable characters.
Bytes	38-39	: Highest ASCII value of displayable characters.
Bytes	40-49	: Relative distances of top, ascent, half, descent, and bottom line from the base line.
Bytes	50-51	: Width of the broadest character in the font.
Bytes	52-53	: Width of the broadest character cell. The cell is always at least one pixel wider than the actual character so that two characters next to each other are separated from each other.
Bytes	54-55	: Linker offset.
Bytes	56-57	: Right offset. The two offset values are used for displaying the font in italics (skewing).
Bytes	58-59	: Thickening. If a character is to be displayed in boldface, this variable is used.
Bytes	60-61	: Underline. Contains line height in pixels.
Bytes	62-63	: Lightening mask. "Light" characters are found on the desktop when an option on a pull-down menu is unavailable. This light grey character consists of masking the bits with the lightening mask. Usually the value is $5555.
Bytes	64-65	: Skewing mask. As before, only for displaying characters in italics.
Bytes	66-67	: Flag. Bit 0 is set if a system font is used. Bit 1 must be set if the horizontal offset table is present. Bit 2 is the so-called byte-swap flag. If it is set, the bytes in memory are in 68000 format (low byte-high byte). A cleared swap flag signals that the data is in INTEL format, reversed in memory. With this bit the fonts from the IBM version of GEM can be used on the ST and vice versa. Bit 3 is set if the width of all characters in the font is equal.
Bytes	68-71	: Pointer to the horizontal offset table or zero.
Bytes	72-75	: Pointer to the character offset table.

```
Bytes 76-79 : Pointer to the font data.
Bytes 80-81 : Form width. This variable contains the sum of
              widths of all the characters. The value
              represents the length of the scan lines of all
              of the characters and thereby the start of the
              next line.
Bytes 82-83 : Form height. This variable contains the number
              of scan lines for this font.
Bytes 84-87 : Contain a pointer to the next font.
```

After so much talk, we should now list the parameters which must be noted or prepared for the $A008 opcode.

```
_WRT_MODE    = Write mode
_TEXT_FG     = Text foreground color
_TEXT_BG     = Text background color
_FBASE       = Pointer to the start of the font data
_FWIDTH      = Width of the font
_SOURCEX     = X-coordinate of the char in the font
_SOURCEY     = Y-coordinate of the char in the font
_DESTX       = X-coordinate of the char on the screen
_DESTY       = Y-coordinate of the char on the screen
_DELX        = Width of the character in pixels
_DELY        = Height of the character in pixels
_STYLE       = Bit-wise coded flag for special effects
_LITEMASK    = Bit pattern used for "lightening"
_SKEWMASK    = Bit pattern used for skewing
_WEIGHT      = Factor for character enlargement
_R_OFF       = Right offset of the char for skewing
_L_OFF       = Left offset of the char for skewing
_SCALE       = Flag for scaling
_XACC_DDA    = Accumulator for scaling
_DDA_INC     = Scaling factor
_T_SCLSTS    = Scaling direction flag
_CHUP        = Character rotation vector
_MONO_STATUS = Flag for monospaced type
_scrtchp     = Pointer to buffer for effects
_scrpt2      = Offset scaling buffer in _scrtchp
```

As you can see, an enormous number of variables are evaluated for the output of graphic text. Here we can go into only the essential (and those we explored) variables.

The write mode allows the output of characters in the four known modes, replace, OR, XOR, and inverse OR. The variable _TEXT_FG is in connection with first four write modes. They form the foreground color used for display. The background color _TEXT_BG plays a role only with the 16 additional modes. It is clear that the additional modes are relevant only in connection with a color screen.

The variables _FBASE and _FWIDTH are set according to the desired font. You can find the start of the font data from the header of the desired font (bytes 76-79 in the header). _FWIDTH must be loaded with the contents of the bytes 80 and 81 of the header.

The parameter _SOURCEX determines which character you output. It should contain the ASCII value of the desired character. The parameter _SOURCEY is usually zero because the character is to be generated from the top to the bottom scan line.

The parameter _DELX can be calculated as the width of the character in which the entry in the character offset table of the desired character is subtracted from the next entry. The result is the width of the character in pixels. _DELY must be loaded with the value of byte 82-83 of the header.

The _STYLE is something special. Here you can specify if characters should be displayed normally or changed. The possible changes are boldface (thicken, bit 0), shading (lighten, bit 1), italic (bit 2), and outline (bit 4). The given change is enabled by setting the corresponding bit. Another change is scaling. The size of a character can be changed through scaling. Unfortunately, characters can only be enlarged on the ST.

If the scaling flag is cleared (zero), the character is displayed in its original size. The _T_SCLSTS flag determines if the font is to be reduced or enlarged. A value other than zero must be placed here for enlarging. _DDA_INC should contain the value of the enlargement or reduction. An enlargement could be produced only with a value of $FFFF.

Another interesting variable is _CHUP. With the help of this variable, characters can be rotated on the screen. The angle must be given in the range 0 to 360 degrees in tenths of a degree. A restriction must also be made for this function. Usable results are obtainable only with rotations by 90 degrees. The values are $0000 for normal, $0384 for 90-degree rotation, $0708 (upside-down type), and $0A8C for 270 degrees.

To work with the effects, _scrchp must contain a pointer to a buffer in which TEXTBLT can store temporary values. The exact size of this buffer is not known, but we always found a buffer of 1K to be sufficient. Another buffer must be specified for enlargement (_scrpt2). An offset is passed as a parameter which refers to the start of the _scrtchp buffer. A value of $40 proved to be sufficient here.

$A009 SHOW MOUSE

Calling this opcode enables the display of the mouse cursor. The cursor follows the mouse when it is moved. If the mouse cursor is disabled, the mouse can be used in programs which abandon the user interface GEM. This option is particularly useful for games.

The parameters required are passed in the Intin and Contrl arrays. Contrl(1) should be cleared before the call and Contrl(3) set to one. Intin(0) has a special significance. The routine for managing the mouse cursor counts the number of calls to remove and enable the cursor. If the cursor is disabled twice, two calls must be made to re-enable it before it will actually appear on the screen. This behavior can be changed by clearing Intin(0). With this parameter the cursor is immediately set independent of the number of previous HIDE CURSOR calls. If the value in Intin(0) is not equal to zero the actually required number of $A009 calls must be made in order to make the cursor visible.

$A00A HIDE CURSOR

This functions hides the cursor. If this function is called repeatedly, the number is recorded by the operating system and determines the number of calls of SHOW CURSOR before the cursor actually appears.

$A00B TRANSFORM MOUSE

Is the arrow unsuited as a mouse cursor for games? Simply make your own cursor. How would it be if a little car moved across the screen instead of an arrow? The opcode $A00B gives your fantasy free reign, at least as far as it concerns the mouse cursor.

The parameters must be passed in the Intin array. A total of 34 words are necessary. The following table lists the uses and possible values:

```
Intin(3) Mask color index, normally 0
Intin(4) Data color index, normally 1
Intin(5) to Intin(20) contain 16 words of the cursor mask
Intin(21) to Intin (36) contain 16 words of cursor data
```

The form of the cursor is determined by the cursor data. Each 1 in the data creates a point on the screen. If a cursor is placed over a letter or pattern on the screen, the border between the cursor and the background cannot be determined. The mask enters at this point. Each set bit in the mask clears the background at the given location. This draws a light border around the cursor. Look at the normal cursor in order to see the operation of the mask.

$A00C UNDRAW SPRITE

This opcode is related to $A00D, DRAW SPRITE. The ST actually has no hardware sprites like the Commodore 64. ST sprites are organized purely in software. Each sprite is 16x16 pixels large. One example of an ST sprite is the mouse cursor. It is created with this function.

To clear a previously-drawn sprite, the address of a buffer in which the background was saved when the sprite was drawn is passed in register A2. The opcode simply transfers the contents of the background buffer to the right spot on the screen. The buffer itself must be 64 bytes large for each plane. Another 10 bytes are used, independent of the number of planes. For monochrome display, the buffer is a total of 74 bytes long, while in the 320x200 pixel resolution (for planes), it is 4x64+10=266 bytes large.

$A00D DRAW SPRITE

This function draws the desired sprite on the screen. Parameters must be passed in the D0, D1, A0, and A2 registers.

D0 and D1 contain the X and Y-coordinates of the position of the sprite on the screen, called the hot spot. A0 is a pointer to the so-called sprite definition block and A2 contains the address of the sprite buffer in which the background will be saved for erasing the sprite later.

The sprite definition block must have the following construction:

```
Word 1 : X offset to hot spot
Word 2 : Y offset to hot spot
```

```
Word 3 : Format flag 0=VDI format, 1=XOR format
Word 4 : Background color (bg)
Word 5 : Foreground color (fg)
```

Following this are 32 words which contain the sprite pattern. The pattern must be in memory in the following order:

```
Word 6 : Background pattern of the top line
Word 7 : Foreground pattern of the top line
Word 8 : Background pattern of the second line
Word 9 : Foreground pattern of the second line
etc.
```

The information in the format flag has the following significance:

```
          VDI Format
fg  bg    Result
 0   0    The background appears
 0   1    The color in word 4 appears
 1   0    The color in word 5 appears
 1   1    The color in word 5 appears

          XOR Format
fg  bg    Result
 0   0    The background appears
 0   1    The color in word 4 appears
 1   0    Th fb bit XORs the pixel on the screen
 1   1    The color in word 5 appears
```

$A00E COPY RASTER FORM

Arbitrary areas of the screen can be copied with the $A00E opcode. Not only areas within the screen, but also from the screen into free RAM, and even more important, from the RAM to the screen. Even complete screen pages can be copied very quickly with the COPY RASTER opcode. The name RASTER FORM does express one limitation of the function, however. Each raster form to be copied must begin on a word boundary and must be a set of words.

The parameters are quite numerous and are passed in the `Contrl`, `Ptsin`, and `Intin` arrays. In addition, two "memory form definition" blocks must be in memory for COPY RASTER. We will start with the MFD blocks.

Since a copy operation must always have a source and a destination, one block describes the source memory range and the second describes the destination. Each block consists of 10 words. The address of the memory described by the block is contained in the first two words. The third word specifies the height of the form in pixels. Word 4 determines the width of the form in words. Word 6 should be set to 1 and word 7 specifies the number of planes of which the form is composed. The remaining words should be set to zero because they are reserved for future extensions.

Necessary parameters for COPY RASTER:

```
INTIN[0]       Bit  0-3
               Opaque:Logical operation; Transparent:
               Writing mode (see $A007, BITBLT)
               Bit 4 = 0: no pattern used;
                     = 1: pattern used
INTIN[1]       Transparent only: 1 bit color index
INTIN[2]       Transparent only: 0 bit color index
PTSIN[0]       Upper left source X-coordinate
PTSIN[1]       Upper left source Y-coordinate
PTSIN[2]       Lower right source X-coordinate
PTSIN[3]       Lower right source Y-coordinate
PTSIN[4]       Upper left destination X-coordinate
PTSIN[5]       Upper left destination Y-coordinate
PTSIN[6]       Lower right destination X-coordinate
PTSIN[7]       Lower right destination Y-coordinate
CONTRL[7+8]    Address source MFDB
CONTRL[9+10]   Address destination MFDB
_patptr        Pattern pointer (when used)
_multifill     0 = pattern has one plane
               1 = pattern has several planes
_COPYTRAN      0 = opaque
               N-plane source and n-plane destination
               1 = transparent
               Source with a plane copied through all
               destination planes (transparent).
```

Memory Form Definition Block (MFDB) design:

```
Offset Size Meaning
  0    long Pointer to raster image
  4    word Raster width in pixels
  6    word Raster height in pixels
```

```
  8     word Raster width in words
 10     word Format flag
             0 = device-specific
             1 = number of bit planes
 12     word Number of bit planes
 14     word Reserved
```

When the COPY RASTER function is used, the raster image in device-specific format must be laid out first. (Standard format arranges the bitplanes one after the other, instead of nesting them by words).

A few remarks about the words "opaque" and "transparent:" Opaque copying simply combines the corresponding color planes of source and destination, as well as the resulting raster, though a logical operation with a value from 0 to 15 (see also $A007, BITBLT). Here the number of color planes in source and destination must match, or else the function stops. Opaque copying doesn't require the values in INTIN[1] and INTIN[2]. Transparent copying copies a source range containing a single color plane to a multicolor destination range. The source range consists of only two different colors, represented by bits 0 and 1. You can determine which color appears in the source range pixels. Give the corresponding color numbers in INTIN[1] and INTIN[2].

In INTIN[0] writing mode is used instead of the logical operations:

```
INTIN[0]    Writing mode
    1       Replace mode
    2       Transparent mode
    3       XOR mode
    4       Reverse transparent mode
```

These procedures serve when a source range is only two colors, and when a monochrome as well as a color screen are used. Monochrome copying naturally displays in black and white; color screens can use the two colors from the available palette. The diskette icons from the Desktop are copied using these procedures.

Copy Raster Opaque is identical in the other respects to the VDI function 109, vro_cpyfm, while Copy Raster Transparent corresponds to the VDI function 121, vrt_cpyfm.

$A00F CONTOUR FILL (FLOOD FILL)

The line-A opcode $A00F is not documented by Atari at present. However, when you look at the program with the help of a disassembler, you can see a $A00x opcode execute. It's much more difficult to determine WHICH function the $A00F opcode performs. Now, this is our mystery to be unraveled. $A00F calls a fill routine. This fill is identical to the VDI function 103 Contour Fill.

Contour Fill requires an XY coordinate and a mode word for parameters. The coordinates are stored in PTSIN(0) and PTSIN(1), the mode word in INTIN(0). The mode word means the following: If we have a positive value, this value is established as the color value. An area is then filled with either the border color or the given color. If the value is negative, the fill is limited to the color of the starting point.

Some of the variables important to this command are clipping, write mode, pattern pointer and pattern mask without multifill.

3.4.1 An overview of the "line-A" variables

After the initialization $A000, D0 and A0 contain the address of a variable area which contains more than 50 line-A variables. The essential variables have been described along with the various calls, but not the location of the variables within the variable block. We will present this list shortly. When naming the variables we have remained with the names used in the official Atari documentation.

Offset is the value which must be given to access the value register relative. Variables supplied with a question mark could not be definitively explained.

Offset	Name	Size	Function
0	v_planes	word	Number of planes
2	v_lin_wr	word	Bytes per scan line
4	Contrl	long	Pointer to the Contrl array
8	Intin	long	Pointer to the Intin array
12	Ptsin	long	Pointer to the Ptsin array
16	Intout	long	Pointer to the Intout array
20	Ptsout	long	Pointer to the Ptsout array
24	_FG_BP_1	word	Plane 0 color value
26	_FG_BP_2	word	Plane 1 color value
28	_FG_BP_3	word	Plane 2 color value
30	_FG_BP_4	word	Plane 3 color value
32	_LSTLIN	word	Should be -1 ($FFFF) (?)
34	_LN_MASK	word	Line pattern for $A003
36	_WRT_MODE	word	Write mode (0=write mode 1=transparent 2=XOR mode 3=Inverse trans.)
38	_X1	word	X1-coordinate
40	_Y1	word	Y1-coordinate
42	_X2	word	X2-coordinate
44	_Y2	word	Y2-coordinate
46	_patptr	long	Fill pattern pointer (see $A004)
50	_patmsk	word	Fill pattern "mask" (see $A004)
52	_multifill	word	0=fill pattern for one plane 1=fill pattern for multiplane
54	_CLIP	word	0=no clipping (see $A005) unequal to 0=clipping
56	_XMN_CLIP	word	define upper left corner of
58	_YMN_CLIP	word	the visible clipping area and
60	_XMX_CLIP	word	define lower right corner of
62	_YMX_CLIP	word	the visible area for clipping
64	_XACC_DDA	word	Should be set to $8000 before each call to TXTBLT (?)
66	_DDA_INC	word	Enlargement/reduction factor $FFFF for enlargement, reduction doesn't work (?)
68	_T_SCLSTS	word	0=reduction (?) 1=enlargement

70	_MONO_STATUS	word	1=no proportional font 0=proportional type or width of character changed by bold or italics
72	_SOURCEX	word	X-coordinate of char in font
74	_SOURCEY	word	Y-coord of char in font (0)

Note: SOURCEX is the value of the character from the horizontal offset table (HOT) and can be calculated with the formula SOURCEX = HOT-element (ASCII value minus FIRST ADE). The variable FIRST ADE is contained in bytes 36,37 of the font header (see example)

76	_DESTX	word	X-position of char on screen
78	_DESTY	word	Y-position of char on screen
80	_DELX	word	Character width
82	_DELY	word	Character height

Note: DELX can be calculated with the formula DELX = SOURCEX+1 minus SOURCEX (see $A008). DELY is the value FORM height from bytes 82,83 of the font header.

84	_FBASE	long	Pointer to start of font data
88	_FWIDTH	long	Width of font form
90	_STYLE	word	Special effects flag (see $A008)
92	_LITEMASK	word	Mask for shading
94	_SKEWMASK	word	Mask for italic type
96	_WEIGHT	word	Number of bits by which the character will be expanded
98	_R_OFF	word	Offset for italic type
100	_L_OFF	word	Offset for italic type

Note: The above five variables should be loaded with the corresponding values from the font header.

102	_SCALE	word	0=no scaling 1=scaling (enlarge/reduce)
104	_CHUP	word	Angle for character rotation 0=normal char representation $384=rotated 90 degrees $708=rotated 180 degrees $A8C=rotated 270 degrees

106	_TEXT_FG	word	Text display foreground color
108	_scrtchp	long	Buffer address required for creating special text effects
112	_scrpt2	word	Offset of the enlargement buffer in the scrtchp buffer
114	_TEXT_BG	word	Background color for text rep
116	_COPYTRAN	word	(?)

3.4.2 Examples for using the line-A opcodes

To make your first experiments with the line-A opcodes easier, here are a few examples to serve you as a starting point. In the first example, $A001 sets a point is set on the screen with $A001, $A002 sets the point's color.

```
*******************************************************
*           Demo of $A000,$A001 and $A002 functions
*******************************************************

Intin       equ     8
Ptsin       equ     12

init        equ     $a000
setpix      equ     $a001
getpix      equ     $a002

start:
            .dc.w   init                call $A000
            move.l  Intin(a0),a3        address of Intin-arrays
            move.l  Ptsin(a0),a4        address of Ptsin-arrays

            move    #300,(a4)           X coordinate
            move    #100,2(a4)          Y coordinate

            move    #1,(a3)             color set, pixel set
                                        0 erases pixel

            .dc.w   setpix              set pixel

            move    #300,(a4)           X coordinate
            move    #100,2(a4)          y coordinate
            .dc.w   getpix              get color value

             d0 now contains color value
```

A monochrome monitor requires only the color values zero and one. Other values can be entered when working in one of the color modes, however.

The next example shows how a triangle can be drawn on the screen with the function FILLED POLYGON.

```
*************************************************
*            a006 - filled polygon
*************************************************

contrl      equ     4
ptsin       equ     12

fg_bp1      equ     24
fg_bp2      equ     26
fg_bp3      equ     28
fg_bp4      equ     30
wrt_mod     equ     36

y1          equ     40

patptr      equ     46
patmsk      equ     50
multifill   equ     52
clip        equ     54
xmn_clip    equ     56
ymn_clip    equ     58
xmx_clip    equ     60
ymx_clip    equ     62

init        equ     $a000
polygon     equ     $a006

            .dc.w   init                get variable block address
                                        from A0

            move.w  #1,fg_bp1(a0)       set colors for
            clr.w   fg_bp2(a0)          monochrome only
            clr.w   fg_bp3(a0)
            clr.w   fg_bp4(a0)
            move.w  #2,wrt_mod(a0)      replace mode

            move.l  #fill,patptr(a0)    pointer to the fill pattern
            move.w  #4,patmsk(a0)       four fill patterns
            clr.w   multifill(a0)       only one plane (monochrome)
            clr.w   clip(a0)            no clipping
            move.l  contrl(a0),a6       Contrl array address from A6
```

```
             addq.l   #2,a6           A6 > Contrl(1)
             move.w   #3,(a6)         the XY pair in Ptsin

             move.l   ptsin(a0),a6    Ptsin array address from A6
             move.l   #tab,a5         Coordinate table
             move.w   #8,d3           receive 8 coordinates
loop         move.w   (a5)+,(a6)+
             dbra     d3,loop

             move.w   #100,d3         first scanline
loop1        move.w   d3,y1(a0)       from Y1
             move.l   a0,-(sp)        store address variable block

             dc.w     polygon         fill scanline, destroy A0

             move.l   (sp)+,a0        restore A0
             addq.w   #1,d3           calculate next scanline
             cmp.w    #301,d3         last scanline?
             bne      loop1           no, next scanline
             rts                      subroutine all done

fill:
             dc.w     %1100110011001100
             dc.w     %0110110110110110
             dc.w     %0011001100110011
             dc.w     %1001100110011001

tab:
             dc.w     320,100
             dc.w     120,300
             dc.w     520,300
             dc.w     320,100
```

The next example shows how to enable the mouse and manipulate the cursor form. The example waits for a key press before returning.

```
**********************************************************
*             show mouse - transform mouse
**********************************************************
intin         equ       8

init_a        equ       $a000
show_mouse    equ       $a009
transmouse    equ       $a00b

start:
              .dc.w     init_a          address Intin from A5
              move.l    Intin(a0),a5
              move      #0,6(a5)        Intin (3) = mask color value
              move      #1,8(a5)        Intin (4) = data color value

              add.l     #10,a5          a5 > Intin (5)

              lea       maus,a4         data for new cursor
              move      #15,d0          32 words = 16 longs

loop:
              move.l    (a4)+,(a5)+     transfer Intin array
              dbra      d0,loop

              .dc.w     transmouse      and set form

              .dc.w     init_a

              move.l    Intin(a0),a0
              clr.w     (a0)            Number Hide Cursor -ignore call

              .dc.w     show_mouse      now the new cursor

              rts                       subroutine all done

maus:
maske:
              .dc.w     %0000000110000000
              .dc.w     %0000011111100000
              .dc.w     %0001111111111000
              .dc.w     %0111111111111110
              .dc.w     %1111111111111111
              .dc.w     %1111001111001111
              .dc.w     %1111001111001111
```

```
          .dc.w     %1111001111001111
          .dc.w     %0000001111000000
          .dc.w     %0000001111000000
          .dc.w     %0000001111000000
          .dc.w     %0000001111000000
          .dc.w     %0000001111000000
          .dc.w     %0000001111000000
          .dc.w     %0000000000000000
daten:
          .dc.w     %0000000000000000
          .dc.w     %0000000000000000
          .dc.w     %0000000110000000
          .dc.w     %0000011001100000
          .dc.w     %0110000110000110
          .dc.w     %0110000110000110
          .dc.w     %0000000110000000
          .dc.w     %0000000110000000
          .dc.w     %0000000110000000
          .dc.w     %0000000110000000
          .dc.w     %0000000110000000
          .dc.w     %0000000110000000
          .dc.w     %0000000110000000
          .dc.w     %0000000000000000
          .dc.w     %0000000000000000
```

3.5 The Exception Vectors

The first 1024 bytes of the 68000 processor are reserved for the exception vectors. Routines which use exception handling store the addresses they require in this range of memory.

A condition which leads to an exception can come either from the processor itself or from the peripheral components and controls units connected to it. The interrupts, described in the next section, belong to the class of external events. In addition, a so-called bus error can be created externally.

A bus error can be created by many circumstances. For one, certain memory areas can be protected from unauthorized access by it. As you may already know, the 68000 can run in one of two operating modes. The operating system is driven at the first level, the *supervisor mode*. The *user mode* is intended for user programs. In order that a user program not be able to access important system variables as well as the system components in an uncontrolled fashion, such an access in the user mode leads to a bus error. If such an error occurs, the processor stops execution of the instruction, saves the program counter and status register on the stack, and branches to a routine, the address of which it fetches from the lowest 1024 bytes of memory. In the case of the bus error, the address is at memory location 8 (one long word). What happens in this routine?

First the vector number of the interrupt is determined and placed in address \$3C4. Then the registers will get up to 16 words from the system stack and store them. Therein is the address by which the interruption occurred, as well as the current system status. In the case of a bus or address error, these words contain the address at which the error occurred, as well as the type of access (see any 68000 user's manual). As many cherry bombs appear on the screen as the interrupt vector number. In the case of a bus error, for example, this number is 2. Execution then returns to the GEM Desktop.

The range in which the above information will be stored retains this information until the ST is reset. It therefore conveys the complete status of the processor until a crash occurs. The data lie at the following addresses:

```
$380  contains  $12345678 when the following data is valid
$384 - $3A3     D0 - D7
$3A4 - $3BF     A0 - A6
```

$3C0	SSP
$3C4	Exception number
$3C8	USP
$3CC - $3EB	16 words from SSP

The following table contains all of the exception vectors.

Vector number	Address	Exception vector meaning
0	$000	Stack pointer after reset
1	$004	Program counter after reset
2	$008	Bus error
3	$00C	Address error
4	$010	Illegal instruction
5	$014	Division by zero
6	$018	CHK instruction
7	$01C	TRAPV instruction
8	$020	Privilege violation
9	$024	Trace
10	$028	Line-A emulator
11	$02C	Line-F emulator
12-14	$030-$038	reserved
15	$03C	Uninitialized interrupt
16-23	$040-$05C	reserved
24	$060	Spurious interrupt
25	$064	Level 1 interrupt
26	$068	Level 2 interrupt
27	$06C	Level 3 interrupt
28	$070	Level 4 interrupt
29	$074	Level 5 interrupt
30	$078	Level 6 interrupt
31	$07C	Level 7 interrupt
32	$080	TRAP #0 instruction
33	$084	TRAP #1 instruction
34	$088	TRAP #2 instruction
35	$08C	TRAP #3 instruction
36	$090	TRAP #4 instruction
37	$094	TRAP #5 instruction
38	$098	TRAP #6 instruction
39	$09C	TRAP #7 instruction
40	$0A0	TRAP #8 instruction
41	$0A4	TRAP #9 instruction
42	$0A8	TRAP #10 instruction
43	$0AC	TRAP #11 instruction

44	$0B0	TRAP #12 instruction
45	$0B4	TRAP #13 instruction
46	$0B8	TRAP #14 instruction
47	$0BC	TRAP #15 instruction
48-63	$0C0-$0FC	reserved
64-255	$100-$3FC	User interrupt vectors

The following vectors are used on the ST:

Line-A emulator	$FC9CA2 / $FB30
Line-F emulator	$A30E / $3A6AE
Level 2 interrupt	$FC061E / $64AC
Level 4 interrupt	$FC0634 / $64C2
TRAP #1 GEMDOS	$FC4D48 / $ABD6
TRAP #2 GEM	$FE340E / $29B76
TRAP #13 BIOS	$FC074E / $65DC
TRAP #14 XBIOS	$FC0748 / $65D6

The first address refers to the ROM version; the second address is read when the operating system is found in RAM. The vector for division by zero points to `rte` and returns directly to the interrupted program. Vectors 64-79 are reserved for the MFP 68901 interrupts. All other vectors point to $FC0A1A/$68A8 which outputs the vector number and ends the program as described for the bus error.

All of the unused vectors can be used for your own purposes, such as the line-F emulator or the 12 unused traps.

3.5.1 The line-F emulator

The ST operating system uses the line-F emulator to replace frequently used command sequences with just one command. Since the better part of the operating system is written in C, especially the AES, you'll often find a sequence at the end of a C subroutine, generated by the compiler:

```
tst.l     (A7)+
movem.l   (A7)+,Dx-Dy/Ax-Ay
unlk      A6
rts
```

This sequence requires 5 words. A 16-bit mask in the `movem` command decides which register will be taken from the stack. Bits 0 - 7 stand for data registers D0 - D7, and bits 8 - 15 are for the address registers (A0 - A7). This mask is ORed by the opcode $F000 to shift the second bit to the right, and set bit 0. Thus it is possible to get the register contents of D3 - D7 and A0 - A5, which are used by the C compiler, from the stack. Four words will be stored during this procedure.

If bit 0 is not set in the line-F command, the opcode will be interpreted as a pointer in a table, from which the address of a routine will be taken. This routine will then branch to the return address previously placed on the stack. The opcode must be divisible by 4; e.g., $F000, $F004, etc., up to $F9CC. The jump table resides at $FEE8BC-$FEF28B or $34B60-$3552F.

Since the line-F routine contains self-modifying code, it is copied into RAM.

```
************************************ LINE-F emulator
00A30E 341F         move.w   (A7)+,D2          Get status from stack
00A310 205F         move.l   (A7)+,A0          Return address
00A312 3218         move.w   (A0)+,D1          Get opcode
00A314 08010000     btst     #0,D1             Bit 0 set?
00A318 6614         bne      $A32E             Yes
00A31A 46C2         move.w   D2,SR             Set status
00A31C 2F08         move.l   A0,-(A7)          Return addr. from stack
00A31E 02410FFF     and.w    #$0FFF,D1         Delete bits 12-15
00A322 207C00FEE8BC move.l   #$FEE8BC,A0       Base address of table
00A328 20701000     move.l   0(A0,D1.W),A0     Get address
00A32C 4ED0         jmp      (A0)              Execute routine
00A32E 02410FFE     and.w    #$0FFE,D1         Delete bits 12-15 and bit 0
00A332 6712         beq      $A346             $F001, then unlk/rts
00A334 E549         lsl.w    #2,D1             Shift mask
00A336 007C07000    or.w     #$700,SR          Save IPL 7, interrupts
00A33A 41FA0008     lea      $A344(PC),A0      Register mask address
00A33E 3081         move.w   D1,(A0)           Copy mask in program
00A340 588F         addq.l   #4,A7             Correct stack
00A342 4CDF2000     movem.l  (A7)+,A5          Get register again
00A346 46C2         move.w   D2,SR             Set status
00A348 4E5E         unlk     A6                release local variables
00A34A 4E75         rts                        Return from call

                    Bit no.   :  FEDCBA9876543210
                    Opcode    :  1111XXXXXXXXXXX1
                    Register  :      AAAAAADDDDD
                                     54321076543
```

3.5.2 The interrupt structure of the ST

The interrupt capabilities offered by the 68000 microprocessor are put to good use in the ST. As you may have already gathered from the hardware description of the processor, the processor has seven interrupt levels with different priorities. The interrupt mask in the system byte of the status register determines which levels can generate an interrupt. An interrupt can only be generated by a level higher than the current contents of the mask in the status register. A interrupt of a certain priority is communicated to the processor by the three interrupt priority level inputs. The following assignment results:

Level	IPL 2	1	0
7 (NMI)	0	0	0
6	0	0	1
5	0	1	0
4	0	1	1
3	1	0	0
2	1	0	1
1	1	1	0
0	1	1	1

If all three lines are 1 (interrupt level 0), no interrupt is present. Interrupt level 7 is the NMI (non-maskable interrupt), which is executed even if the interrupt mask in the status register contains seven. Which interrupt is assigned which vector (that is, the address of the routine which will process the interrupt) depends on the peripheral component which generates the interrupt. For auto-vectors, the processor itself derives the interrupt number from the interrupt level. The following table is used in this process:

Level	Vector number	Vector address
IPL 1	25	$64
IPL 2	26	$68
IPL 3	27	$6C
IPL 4	28	$70
IPL 5	29	$74
IPL 6	30	$78
IPL 7	31	$7C

Only lines IPL 1 and IPL 2 are used on the Atari ST; Line IPL is permanently set to a 1 level so that only levels 2, 4 and 6 are available. The results in the following assignment:

```
IPL 2        HBL, horizontal blank, line return
IPL 4        VBL, vertical blank, picture return
IPL 6        MFP 68901
```

The HPL interrupt is generated on each line return from the video section. It is generated every 50 to 64 μs depending on the monitor connected (monochrome or color). It occurs very often and is normally not permitted by an interrupt mask of three. The standard HBL routine therefore only has the task of setting the interrupt mask to three if it is zero and allows the HBL interrupt so that no more HBL interrupts will occur. One use of the HBL interrupt could be for special screen effects. With the help of this routine, you know exactly which line of the screen has just been displayed. Of much greater importance, however, is the VBL interrupt, which is generated on each picture return. This occurs 50, 60, or 70 times per second depending on the monitor.

The vertical blank interrupt (VBL) routine accomplishes a whole set of a tasks which must be periodically executed or which concern the screen display. When entering the routine, the frame counter `_frclock` ($466) is first incremented. Next, a test is made to see if the VBL interrupt is software-disabled. This is the case if `vblsem` ($452) (vertical blank semaphore) is zero or negative. In this case the routine is exited immediately and execution returns to the interrupted program. Otherwise, all of the registers are saved on the stack and the counter `_vbclock` ($462), which counts the executed VBL routines, is incremented. Next, a check is made to see if a different monitor has been connected in the meantime. If a change was made from a monochrome to color monitor, the video shifter is reprogrammed accordingly. This is necessary because the high screen frequency of 70 Hz of the monochrome monitor could damage a color monitor. The routine to flash the cursor is called next. If you load a new color palette via the appropriate BIOS functions or want to change the screen address, this happens here in the VBL routine. Since nothing is displayed at this time, a change can be made here without disturbing anything else. If `colorptr` ($45A) is not equal to zero, it is interpreted as a pointer to a new color palette, and this is loaded into the video shifter. The pointer is then cleared again. If `screenptr` is set, this value is used as the new base address of the screen. This takes care of the screen specific portions.

Now the floppy VBL routine is called which, with the help of the write protect status, determines if a diskette was changed. An additional task of this routine is to deselect the drives after the disk controller has turned the drive motor off.

Now comes the most interesting part for the programmer, the processing of the VBL queue. There is a way to tell the operating system to execute your own routines within the VBL interrupt. The maximum number of routines possible is in `nvbls` ($454). This value is normally initialized to 8, but it can be increased if required. Address `_vblqueue` ($456) contains a pointer to a vector array which contains the (8) addresses of the VBL routines. Each address is tested within the VBL routine and the corresponding routine executed if the address is not zero.

If you want to install your own VBL routine, check the 8 entries until you find one which contains a zero. At this address you can write a pointer to your routine which from now on will be executed in every VBL interrupt. In all 8 entries are already occupied, you can copy the entries into a free area of memory, append the address of your routine, and redirect `_vblqueue` to point to the new vector array. Naturally, you must not forget to increment `vbls`, the number of routines, correspondingly. Your routine may change all registers with the exception of the USP.

As soon as the VBL routine is done, the `_dmpflg` ($4EE) is checked. If this memory location is zero, a hardcopy of the screen is outputted. The flag is set in the keyboard interrupt routine if the keys ALT and HELP are pressed at the same time. Finally, the register contents are restored, `vblsem` is released and execution returns to the interrupted routine.

The MFP 68901 occupies interrupt level six in our previous table. This component is in the position to create interrupt vectors on its own. These are referred to non-auto vectors in contrast to the auto vectors used above, because the processor does not generate the vector itself. In the Atari ST, the MFP 68901 works as the interrupt controller. It manages the interrupt requests of all peripheral components including its own.

The MFP can manage sixteen interrupts which are prioritized in reference to each other, similar to the seven levels of the processor. All MFP interrupts appear on level 6 to the 68000, therefore prioritized higher than HBL and VBL interrupts. The table on the next page contains the assignments within the MFP.

Level	Assignment
15	Monochrome monitor detect
14	RS-232 ring indicator
13	System clock timer A
12	RS-232 receive buffer full
11	RS-232 receive error

Level	Assignment
10	RS-232 transmit buffer empty
9	RS-232 transmit error
8	Line return counter, timer B
7	Floppy controller and DMA
6	Keyboard and MIDI ACIAs
5	Timer C
4	RS-232 baud rate generator, timer D
3	unused
2	RS-232 CTS
1	RS-232 DCD
0	Centronics busy

Not all of these possible interrupt sources are enabled, however. Some signals are processed through polling. The following is a description of the interrupts which are used by the operating system.

Level 2, RS-232 CTS, address $FC26B2 / $8540

This interrupt is generated every time the RS-232 interface is informed via the CTS line that a connected receiver is ready to receive additional data. The routine then sends the next character from the RS-232 transmit buffer.

Level 5, Timer C, address $FC2F78 / $8E06

This timer runs at 200 Hz. The 200 Hz counter at $4BA is first incremented in the interrupt routine. The next actions are performed only every fourth call to the interrupt routine, that is, only every 20ms (50 Hz). First a routine is called which handles the sound processing. Another task of this interrupt is the keyboard repeat when a key is pressed and initial repeat. Finally, the `evt_timer` routine of GEM is called, which is accessed via vector $400.

Level 6, Keyboard and Midi, address $FC281C / $86AA

Two peripheral components are connected to this interrupt level of the MFP, the two ACIAs which receive data from the keyboard and the MIDI interface. In order to decide which of the two components has requested an interrupt, the interrupt request bits in the status registers of the ACIAs are tested and the received byte is fetched if required. If it comes from the keyboard, the scan code is converted to the ASCII code by means of the

keyboard table and written into the receive buffer, which happens immediately for MIDI data. Mouse and joystick data also come from the keyboard ACIA and are also prepared accordingly.

Level 9, RS-232 transmit error, address $FC2718 / $85A6

If an error occurs while sending RS-232 data, this interrupt routine is activated. Here the transmitter status register is read and the status is saved in the RS-232 parameter block.

Level 10, RS-232 transmit buffer empty, address $FC2666 / $84F4

Each time the MFP has completely outputted a data byte via the RS-232 interface, it generates this interrupt. It is then ready to send the next byte. If data is still in the transmit buffer, the next byte is written into the transmit register, which can now be shifted out according to the selected baud rate.

Level 11, RS-232 receive error, address $FC26FA / $8588

If an error occurs when receiving RS-232 data, this interrupt routine is activated. This may involve a parity error or an overflow. The routine only clears the receiver status register and then returns.

Level 12, RS-232 receive buffer full, address $FC2596 / $8424

If the MFP has received a complete byte, this interrupt occurs. Here the character can be fetched and written into the receive buffer (if there is still room). This routine takes into account the active handshake mode (sending XON/XOFF or RTS/CTS).

The other interrupt possibilities of the MFP are not used, but they can be used for your own routines. For example, interrupt level 0, Centronics strobe, can be used for buffered printer output.

3.6 The Atari ST VT52 Emulator

There are two options for text output on the ST. You can work with the GEMDOS functions by means of `TRAP#1` or a direct BIOS call with `TRAP#13`. The other possibility consists of using the VDI functions.

You have special options for screen control with both variants. We will first take a look at output using the normal DOS or BIOS calls. Here a terminal of type VT52, which offers a wide variety of control functions, is emulated for screen output. These control characters are prefixed with a special character, the escape code. Escape, or ESC for short, has an ASCII code of 27. Following the escape code is a letter which determines the function, as well as additional parameters if required. The following list contains all of the control codes and their significance.

ESC A Cursor up

This function moves the cursor up one line. If the cursor was already on the top line, nothing happens.

ESC B Cursor down

This ESC sequence positions the cursor one line down. If the cursor is already on the bottom line, nothing happens.

ESC C Cursor right

This sequence moves the cursor one column to the right.

ESC D Cursor left

Moves the cursor one position to the left. This function is identical to the control code backspace (BS, ASCII code 8). If the cursor is already in the first column, nothing happens.

ESC E Clear Home

This control sequence clears the entire screen and positions the cursor in the upper left corner of the screen (home position).

ESC H Cursor home

With this function you can place the cursor in the upper left corner of the screen without erasing the contents of the screen.

ESC I Cursor up

This sequence moves the cursor one line towards the top. In contrast to ESC A, however, if the cursor is already in the top line, a blank line is inserted and the remainder of the screen is scrolled down a line correspondingly. The column position of the cursor remains unchanged.

ESC J Clear below cursor

By means of this function, the rest of the screen below the current cursor position is cleared. The cursor position itself is not changed.

ESC K Clear remainder of line

This ESC sequence clears the rest of the line in which the cursor is found. The cursor position itself is also cleared, but the position is not changed.

ESC L Insert line

This makes it possible to insert a blank line at the current cursor position. The remainder of the screen is shifted down; the lowest line is then lost. The cursor is placed at the start of the new line after the insertion.

ESC M Delete line

This function clears the line in which the cursor is found and moves the rest of the screen up one line. The lowest screen line then becomes free. After the deletion, the cursor is moved up to the first column of the line that takes the place of the deleted line.

ESC Y Position cursor

This is among the most important functions. It allows the cursor to be positioned at any place on the screen. The function needs the cursor line and column as parameters, which are expected in this order with an offset of 32. If you want to set the cursor to line 7, column 40, you must output the sequence ESC Y CHR$(32+7) CHR$(32+40). Lines and columns are counter starting at zero; for an 80x25 screen the lines are numbered from 0 to 24 and the columns from 0 to 79.

The remaining ESC sequences of the VT52 terminal start with a lower case letter.

ESC b Select character color

With this function you can select the character color for further output. With a monochrome monitor you have choice between just 0=white and 1=black. For color display you can select from 4 or 16 colors depending on the mode. Only the lowest four bits of the parameters are evaluated (mod 16). You can use the digit "1" for the color 1 as well as the letters "A" or "a" in addition to binary one.

ESC c Select background color

This function serves to select the background color in a similar manner. If you choose the same color for character and background, you will, of course, not be able to see text output any more.

ESC d Clear screen to cursor position

This sequence causes the screen to be erased starting at the top and going to the current position of the cursor, inclusive. The position of the cursor is not changed.

ESC e Enable cursor

Through this escape sequence the cursor becomes visible. The cursor can, for example, be enabled when waiting for input from the user.

ESC f Disable cursor

Turns the cursor off again.

ESC j Save cursor position

If you want to save the current position of the cursor, you can use this sequence to do so. Unfortunately, this function is also used by other ESC sequences, so the stored value is no longer available to you if you use some other sequences.

ESC k Set cursor to the saved position

This is the counterpart of the above function. It sets the cursor to the position which was previously saved with ESC j. If no cursor position was saved, the cursor will go to the home position.

ESC l Clear line

Clears the line in which the cursor is located. The remaining lines remain unaffected. After the line is cleared, the cursor is located in the first column of the line.

ESC o Clear from start

This clears the current cursor line from the start to the cursor position, inclusive. The position of the cursor remains unchanged.

ESC p Reverse on

The reverse (inverted) output is enabled with this sequence. For all further output, the character and background colors are exchanged. A monochrome monitor will show white type on a black background.

ESC q Reverse off

This sequence serves to re-enable the normal character display mode.

ESC v Automatic overflow on

After executing this sequence, an attempted output beyond the end of line will automatically start a new line.

ESC w Automatic overflow off

This deactivates the above sequence. An attempt to write beyond the line will result in all following characters being written in the last column.

Similar functions are available to you under VDI. The VDI escape functions (opcode 5) serve this purpose. The appropriate screen function is selected by choosing the proper function number. Note, however, that under VDI the line and column numbering does not begin with zero but with one.

Under VDI there is also a function which outputs a string at specific screen coordinates. If necessary, you can use the ESC functions of the VT52 emulation in addition.

The output of "unprintable" control characters

The three system fonts of the ST have also been supplied with characters for the ASCII codes zero to 31, which are normally interpreted as control codes. On the ST, only codes 7 (BEL), 8 (BS backspace), 9 (TAB), as well as 10, 11, and 12 (LF linefeed, VT vertical tab, and FF form feed all generate a linefeed) plus 13 (CR carriage return) have effect, in addition to ESC. The remaining codes have no effect. How do we access the characters below 32?

To do this, an additional device number is provided in the BIOS function 3 "conout". Normally number 2 "con" serves for output to the screen. If one selects number 5, however, all the codes from, 0 to 255 are outputted as printable characters, control codes are no longer taken into account.

You will find the three ST system fonts pictured in the Appendix.

3.7 The ST System Variables

The ST uses a set of system variables whose significance and addresses will not change in future versions of the operating system. If you use other variables, such as those from the BIOS listing which are not listed here, you should always remember that these could have a different meaning in a new version of the operating system. The system variables are in the lower RAM area directly above the 68000 exception vectors, at address $400 to 1024. The address range from 0 to $7FF (2047) can be accessed only in the supervisor mode. An access in the user mode leads to a bus error.

In the following listing we will use the original names from Atari. In addition to the address of the given variable, typical contents and the significance will be described. Two values are sometimes given for one address: The first signifies the address in the ROM version of the operating system, while the second address refers to the operating system when in RAM, unless stated otherwise in the text.

```
Address length   name          sample contents
```

$400   L   etv_timer $FCA62A / $104B8

This is the GEM event timer vector. It handles periodic GEM tasks.

$404   L   etv_critic $FC0744 / $65D2

Critical error handler. Under GEM this pointer points to $FE3226/$294DE. There an attempt is made to correct disk errors, such as if a another disk is requested in a single-drive system.

$408   L   etv_term $FC05C0 / $644E

This is the GEM vector for ending a program.

$40C   5L   etv_xtra

Here is space for 5 additional GEM vectors, presently not yet used.

$420   L   memvalid $752019F3

If the memory location contains the given value, the configuration of the memory controller is valid.

`$424 W memctrl $05`

This is a copy of the configuration value in the memory controller. The value given applies for a 1MB machine.

`$426 L resvalid $31415926`

A given value located here causes a jump to the reset vector ($42A).

`$42A L resvector $FC0008`

See above.

`$42E L phystop $80000 / $100000`

This is the physical end of the RAM memory; $80000 for a 512K machine and $100000 for a 1MB machine.

`$432 L _membot $A100 / $39FF0`

The user memory begins here (TPA, transient program area).

`$436 L _memtop $F8000`

This is the upper end of the user memory.

`$43A L memval2 $237698AA`

This value and "memvalid" declare the memory configuration.

`$43E W flock 0`

If this variable contains a value other than zero, a disk access is in progress and the VBL disk routine is disabled.

`$440 W seekrate 3`

The seek rate (the time it takes to move the read/write head to the next track) is determined according to the following table:

Seek rate	Time
0	6 ms
1	12 ms
2	2 ms
3	3 ms

$442 W _timer_ms $14, 20 ms

The time span between two timer calls, 20 ms corresponds to 50 Hz.

$444 W _fverify $FF

If this memory location contains a value other than zero, a verify is performed after every disk write access.

$446 W _bootdev 0

Contains the device number of the drive from which the operating system was loaded.

$448 W palmode 0

If this variable contains a value other than zero, the system is in the PAL mode (50 Hz); if the value is zero, it means the NTSC mode.

$44A W defshiftmod 0

If the Atari is switched from monochrome to color, it gets the new resolution from here (0=low, 1 medium resolution).

$44C W sshiftmd $2

Here is a copy of the register contents for the screen resolution.

```
0   320x200, low resolution
1   640x200, medium resolution
2   640x400, high resolution
```

$44E L _v_bas_ad $F8000

This variable contains a pointer to video RAM (logical screen base). The screen address must always begin on a 256 byte boundary.

$452 W vblsem 1

If this variable is zero, the vertical blank routine is not executed.

$454 W nvbls 8

Number of vertical blank routines.

$456 L _vblqueue $4CE

Pointer to a list of `nvbls` routines which will be executed during the VBL.

$45A L colorptr 0

If this value is not zero, it is interpreted as a pointer to a color palette which will be loaded at the next VBL.

$45E L screenpt 0

This is a pointer to the start of the video RAM, which will be set during the next VBL (zero if no new address is to be set).

$462 L _vbclock $2D26A

Counter for the number of VBL interrupts.

$466 L _frclock $2D267

Number of VBL routines executed (not disabled by vblsem).

$46A L hdv_init $FC0D60 / $6BEE

Vector for hard disk initialization.

$46E L swv_vec $FC0020 / $6120

Vector for monitor change. A branch is made through this vector when another monitor (color/monochrome) is connected (default is reset).

$472 L hdv_bpb $FC0DE6 / $6C74

Vector to get the parameter block for a hard disk (BIOS function 7).

$476 L hdv_rw $FC10D2 / $6F60

Read/write routine vector for a hard disk (BIOS function 4).

$47A L hdv_boot $FC137C / $720A

Vector for loading a boot sector.

$47E L hdv_mediach $FC0F96 / $6E24

Media change routine vector for hard disk (BIOS function 9).

$482 W _cmdload 0

If the boot program sets this variable to a value other than zero, the ST attempts to load a program called "COMMAND.PRG" once the operating system loads (e.g. an application other than the Desktop).

$484 B conterm 6

Attribute vector for console output:

```
Bit  Meaning
 0   Key click on/off
 1   Key repeat on/off
 2   Tone after CTRL G on/off
 3   "kbshift" is returned in bits 24-31 for the
     BIOS function "conin"
```

$48E 4L themd 0

Memory descriptor, filled out by the BIOS function `getmpb`.

$49E 2W ____md 0

Space for additional memory descriptors.

$4A2 L savptr $90C

Pointer to a save area for the processor registers after a BIOS call.

$4A6 W _nflops 2

Number of connected floppy disk drives (0 or 2).

$4A8 L con_state $FC41BC / $A04A

Vector for screen output; set by ESC functions to the appropriate routine, for example.

$4AC W save_row 0

Temporary storage for positioning the cursor with ESC Y.

$4AE L sav_context 0

Pointer to a temporary areas for exception handling.

$4B2 2L _bufl $60A4, $60CC

Pointer to two buffer list headers of GEMDOS. The first header is responsible for data sectors, the second for the FAT (file allocation table) and the directory. Each buffer control block (BCB) is constructed as follows:

```
long   BCB     $4F8A,  pointer to next BCB
int    drive   -1,     drive number or -1
int    type    2       buffer type
int    rec     $41C    record number in this buffer
int    dirty   0       dirty flag (buffer changed)
long   DMD     $2854   pointer to drive media descriptor
long   buffer  $4292   pointer to the buffer itself
```

$4BA L _hz_200 $71280

Counter for 200 Hz system clock

$4BE 4B the_env 0

Default environment string, four zero bytes.

$4C2 L _drvbits 3

32-bit vector for connected drives. Bit 0 stands for drive A, bit 1 for drive B, and so on.

$4C6 L _dskbufp $167A

Pointer to a 1024-byte disk buffer. The buffer is used for GSX graphic operations and should not be used by interrupt routines.

$4CA L _autopath 0

Pointer to autoexecute path.

$4CE 8L _vbl_list $FD03C4,0,0.. / $16252,0,0..

List of the eight standard VBL routines.

$4EE W _dumpflg $FFFF

This flag is incremented by one when the ALT and HELP keys are pressed simultaneously. A value of one generates a hardcopy of the screen on the printer. A hardcopy can be interrupted by pressing ALT HELP again.

$4F2 L _sysbase $FC0000 / $6100

Pointer to start of the operating system.

$4F6 L _shell_p 0

Global shell information.

$4FA L end_os $A100 / $3A4A0

Pointer to the end of the operating system in RAM, start of the TPA.

$4FE L exec_os $FD8E98 / $1F600

Pointer to the start of the AES. Normally branched to after the initialization of the BIOS.

$502 L dump_vec $FC0C2C / $6ABA

This vector is jumped to when a hardcopy is being printed (XBIOS function 20).

$506 L prt_stat $FC1F34 / $7D2E

Printer status vector for hardcopy.

$50A L prt_vec $FC1EA0 / $7D2E

Printer output vector for hardcopy.

$50E L aux_stat $FC1F6E / $7DFC

Vector for getting serial output status during hardcopy.

`$512    L    aux_vec           $FC1F86 / $7E14`

Vector for serial output of the hardcopy function.

`$51A    L    memval3           $5555AAAA`

Contains the variable of the "magic number" memval. Keeps the memory configuration constant after a reset (together with memvalid and memvalid2).

```
$51E    8L    bconstat_vec    $FC0670,$FC2138,$FC2226,
                               $FC2044,$FC0670,$FC0670,
                              $FC0670,$FC0670
```

Eight pointer to routines for getting input status (BIOS function 1, bconstat). The first value applies to device number 0, the next for device 1, etc., up to device 7. The address $FC0670 points direct to an rts command.

```
$53E    8L    bconin_vec      $FC2104,$FC2150,$FC223C,
                               $FC2060,$FC0670,$FC0670,
                              $FC0670,$FC0670
```

The vector table has an equivalent function to the above. There, however, the addresses for BIOS function 2 (bconin) are kept.

```
$55E    8L    bcostat_vec     $FC2124,$FC219A,$FC226C,
                               $FC21DC,$FC2004,$FC0670,
                              $FC0670,  $FC0670
```

These addresses contain the output status for device numbers 0 to 7. They are jumped to from BIOS function 8, bcostat.

```
$57E    8L    bconout_vec     $FC2090,$FC21B4,$FC434C,
                               $FC2016,$FC21EE,$FC4340,
                              $FC0670,  $FC0670
```

These addresses are the ones for character output. These correspond to the BIOS function 3, bconout.

3.8 The 68000 Instruction Set

If you are already familiar with the machine language of some 8-bit processor, forget everything you know. If you do, it will make it easier to understand the following material!

The 68000 processor is fundamentally different in construction and architecture from previous processors (including the 8086!). The essential difference does not lie in the fact that the standard processing width is 16 and not 8 bits (which is sometimes a drawback and can lead to programming errors), but in the fact that, with certain exceptions, the internal registers are not assigned to a specific purpose, but can be viewed as general-purpose registers, with which almost anything is possible.

In earlier processors, the accumulator was always the destination for arithmetic operations, but it is completely absent in the 68000. There are eight data registers (D0-D7) with a width of 32 bits, and as a general rule, at least one of these is involved in an operation. There are also eight address registers (A0-A7), each with 32 bits, which are usually used for generating complex addresses. Register A7 has a set assignment--it serves as the stack pointer. It is also present twice, once as the user stack pointer (USP) and once as the supervisor stack pointer (SSP). The distinction is made because there are also two operating modes, namely the user mode and the supervisor mode.

These two are not only different in that they use different stack pointers, but in that certain instructions are not legal in the user mode. These are the so-called privileged instructions (see also instruction description), with whose help an unwary programmer can easily "crash" the system rather spectacularly. This is why these instructions create an exception in the user mode. An exception, by the way, is the only way to get from the user mode to the supervisor mode.

In addition there is the status register, the upper half of which is designated as the system byte because it contains such things as the interrupt mask, things which do not concern the "normal" user, making access to this byte also one of the privileged instructions. The lower byte, the user byte, contains the flags which are set or cleared based on the result of operations, such as the carry flag, zero flag, etc. As a general rule, the programmer works with these flags indirectly, such as when the execution of a branch is made conditional on the state of a flag.

Two things should be mentioned yet: Multi-byte values (addresses or operands) are not stored in memory as they are with 8-bit processors, in the order low byte/high byte, but the other way around. Four-byte expressions (long word) are stored in memory (and the registers of course) with the highest-order byte first.

The second is that unsupported opcodes do not lead to a crash, but cause a special exception, whose standard handling must naturally be performed by the operating system.

3.8.1 Addressing modes

This is probably the most interesting theme of the 68000 because the enormous capability first takes effect through the many various addressing modes.

The effective address (the address which, sometimes composed of several components, finally determines the operand) is fundamentally 32 bits wide, even if one or more the components specified in the instruction is shorter. These are always sign-extended to the full 32-bit width.

The charm of the addressing lies in the fact that almost all instructions (naturally with exceptions), both the source and destination operands, can be specified with one of the addressing modes. This means that even memory operations do not necessarily have to use one of the registers; memory-to-memory operations are possible.

In the assembler syntax, the source operand is given first, followed by the destination operand (behind the comma).

Register Direct

The operand is located in a register. There are two kinds of register direct addressing: data register direct and address register direct.

In the first case, the operand may be bit, byte, word, or long word-oriented; in the second case a word or long word is required, in case the address register is the destination of the operation.

Example: `ADD.B D0,D1 or ADDA.W D0,A2`

Absolute Data Addressing

The operand is located in the address space of memory. This can also be a peripheral component, naturally (see `MOVEP`). The address is specified in absolute form.

This can have a width of a long word, whereby the entire address space can be accessed, or it can be only one word wide. In this case is sign-extended (the sign being the highest-order bit) to 32 bits. For example, the word $7FFF becomes the long word $00007FFF, while $FFFF becomes $FFFFFFFF. Only the lower 32K and the upper 32K of the address space can be accessed with the short form. This addressing mode is often used in the operating system of the ST because important system variables are stored low in memory and all peripheral components are decoded at the top.

Example: `MOVE.L $7FFF,$01234567`

Instructions in which both operands are addressed with a long word are the longest instructions in the set, consisting of 10 bytes.

Program Counter Relative Addressing

This addressing mode allows even constants to be addressed in a completely relocatable program, since the base of the address calculation is the current state of the program counter.

The are two variations. In the first, a 16-bit signed offset is added to the program counter, and in the second, the contents of a register (sign-extended if only one word is specified) are also added in, though here the offset may be only 8 bits long.

Example: `MOVE.B $1234(PC),$12(PC,D0.W)`

Register Indirect Addressing

There are several variations of this, and they will be discussed individually.

Register Indirect

Here the operand address is located in an address register.

Example: `CLR.L (A0)`

Postincrement Register Indirect

The operand is addressed as above, but the contents of the address register are incremented by the operand length, by 1 for xxx.B or 4 for xxx.L.

Example: `MOVE.B #0,(A0+),(A1)+ or CMP.L #23,(A1)+`

Predecrement Register Indirect

Here the address register is decrement by the length of the operand before the addressing.

Example: `CMPI.W $0123,-(A3)`

Register Indirect with Offset

A 16 bit offset will be added to the contents of the address register.

Example: `EOR.L D0,$1234(A4)`

Indexed Register Indirect with Offset

As above, but the contents of another register (address or data) are also added in, taking the sign into account. The offset may have a width of 8 bits here, however.

Example: `MOVE.W $12(A5,A6.L),D1`

Immediate Addressing

Here the operand is contained as such in the instruction itself. Naturally, an operand specified in this manner can serve only as a source. The immediate operands can, as a general rule, be any of the allowed widths.

Example: `ADDI.W #$1234,D5`

In the variant QUICK, the constant may be only 3 bits long, therefore having a value from 0-7. An exception is the MOVE command, where the constant may have 8 bits, but in which only a data register is allowed as the destination.

Example: `ADDQ.L #1,A0 or MOVEQ #123,D1`

Implied Register

This addressing mode is mentioned only for the sake of completeness and in it, an operand address is already determined by the instruction itself. The operands are either in the program counter, in the status register, or the system stack pointer.

Example: `MOVE SR,D6`

Regarding the offsets, it should be noted that they are signed numbers in two's complement. Their highest-order bit forms the sign. With an 8-bit value, an offset of +127/-128 is possible, and about ±32K with 16 bits.

3.8.2 The instructions

In the following instruction description, the individual bit patterns are not listed since this would lead us too far in this connection. Additional information can be gathered from books like the *M68000 16/32-Bit Microprocessor Programmer's Reference Manual* (Motorola).

The instructions are also explained only in their base form and variations are mentioned only in name. We will briefly explain what the individual variations can look like here.

The variations are indicated by letter after the operand. This can be one of the following:

A indicates that the destination of the operation is an address register. Word operations are sign-extended to 32 bits.

I indicates an immediate operand as the source of the operation. I operands may assume all widths as a general width.

Q means quick and represents a special form of immediate addressing. Such an operand is usually three bits wide, corresponding to a value range of 0 to 7. This limited range has the advantage that the operand will fit into the opcode. Since there is no special command for incrementing a register, something like ADDQ.L #1,A0 works well in its place. An exception is MOVEQ. Here the operand may have a value of 0-255.

X indicates arithmetic operations which use the X flag. This flag has a special significance. It is set equal to the carry flag for all arithmetic operations. The carry flag, however, is also affected by transfer operations while the X flag is not so that it remains available for further calculations. This is especially useful for computations with higher precision than the standard 32 bits, where temporary results must first be saved, and where the carry flag can be changed as a result.

All instructions have a suffix after the opcode of the form .B, .W, or .L. This suffix indicates the processing width of the operation. Although a data register, for example, has a width of 32 bits = 4 bytes = 1 long word, the instruction CLR.B D0 clears only the lowest-order byte of the register. For registers, .W specifies the lower word. The higher-order word is not

explicitly addressable. If the operand is in memory, it is important to know that .W and .L operands must begin on an even address. The same applies for the opcode as such, which also always comprises one word.

If the destination of an operation is an address register, only operands of type .W and .L are allowed, whereby the first is sign-extended to a long word.

Some listings contain instructions of the form MOVE.L #27,D0. The programmer then assumes that the assembler will produce #$0000001B from #27.

Now to the individual instructions:

ABCD Add Decimal with Extend

There is one data format which we have not yet discussed: the BCD format. This means nothing more than "Binary-Coded Decimal" and it uses digits in the range 0-9. Since this information requires only 4 bits, a byte can store a two-digit decimal number. The instruction ABCD can then add two such numbers. The processing width is always 8 bits.

ADD Add Binary

This instruction simply adds two operands.
Variations are *ADDA, ADDQ, ADDI,* and *ADDX.*

AND Logical AND

Two operand are logically combined with each other according the AND function.
Variation: *ANDI*

ASL Arithmetic Shift Left

The operand is shifted to the left byte by the number of positions given, whereby the highest-order bit is copied into the C and X flags. A 0 is shifted in at the right. If a data register is shifted, the processing width can be any. The number of places to be shifted is either specified as an I operand (3 bits) or is placed in an additional register. If a memory location is shifted, the processing width is always one word. A counter is then not given; it is always =1.

ASR Arithmetic Shift Right

The operand is shifted to the right, whereby the lowest bit is copied to C and X. The sign bit is shifted over from the left. See ASL for information about processing width and counter.

Bcc Branch Conditionally

The branch destination is always a relative address which is either one byte or one word long (signed!). Correspondingly, the branch can jump over a range of +127/-128 bytes or +32K-1/-32K. The point of reference is the address of the following instruction.

Whether or not this instruction is actually executed depends on the required condition, which is verified by means of the flags. Here are the variations and their conditions. A minus sign before a flag indicates that it must be cleared to satisfy the condition. Logical operations are indicated with "*" for AND and "/" for OR.

```
BRA  Branch Always              no condition
BCC  Branch Carry Clear         -C
BCS  Branch Carry Set           C
BEQ  Branch Equal               Z
BGE  Branch Greater or Equal    N*V/-N*-V
BGT  Branch Greater Than        N*V*-Z/-N*-V*-Z
BHI  Branch Higher              -C*-Z
BLE  Branch Less or Equal       Z/N*-V/-N*V
BLS  Branch Lower or Same       C/Z
BLT  Branch Less Than           N*-V/-N*V
BMI  Branch Minus               N
BNE  Branch Not Equal           -Z
BPL  Branch Plus                -N
BVC  Branch Overflow Clear      -V
BVS  Branch Overflow Set        V
```

BCHG Bit Test and Change

The specified bit of the operand will be inverted. The original state can be determined from the Z flag. The operand is located either in memory (width=.B) or in a data register (width=.L). The bit number is given either as an I operand or is located in a data register.

BCLR Bit Test and Clear

The specified bit is cleared. Everything else is handled as per BCHG.

BSET Bit Test and Set

The specified bit is set. Boundary conditions are per BCHG.

BSR Branch to Subroutine

This is an unconditional branch to a subroutine. Branch distances as for Bcc.

BTST Bit Test
The bit is only tested as to its condition. Everything else as per BCHG.

CHK Check Register Against Boundaries
A data register is checked to see if its contents are less than zero or greater than the operand. Should this be the case, the processor executes an exception. The program is continued at the address in memory location $18 (vector 6). Otherwise no action is taken. The processing width is only word.

CLR Clear Operand
The specified operand is cleared (set to zero).

CMP Compare
The first operand is subtracted from the second without changing either of the two operands. Only the flags are set, according to the result.
Variations: *CMPA* and *CMPI*
Both operands are addresses with the addressing mode (Ax)+ with the variant *CMPM*.

DBcc Test Condition, Decrement and Branch
A data register (word) is decremented and the flags are checked for the specified condition. A branch is performed if the condition is *not* fulfilled *and* the register is not -1. Branch conditions and ranges as per Bcc.

DIVS Divide Signed
The second operand is divided by the first operand, taking the sign into account. Afterwards the second operand contains the integer quotient in the lower word and the remainder in the upper word, which has the same sign as the quotient. The data width of the first operand is set at .W and at .L for the second.

DIVU Divide Unsigned
Operation as above, but the sign is ignored.

EOR Exclusive OR
The two operands are logically combined according to the rules of EXOR.
Variations: *EORI*

EXG Exchange Registers
The two registers specified are exchanged with each other.

EXT Sign Extend
The operand is filled to the given processing width with its bit 7 (in the case of .B) or bit 15 (.W).

JMP Jump
Unconditional jump to the specified address. The difference between this and BRA is that here the address is not relative but absolute, that is, the actual jump destination.

JSR Jump to Subroutine
Jump to a subroutine. The difference from BSR is as above.

LEA Load Effective Address
This often-misunderstood instruction loads an address register not with the contents of the specified operand address as is normal for the other instructions, but *with the address as such*!

LINK Link Stack
This instruction first places the given address register on the stack. The contents of the stack pointer (A7) are then placed in this register and the offset specified is added to the stack pointer.

With this practical instruction, data areas can be reserved for a subroutine, without having to make room in the program itself, which would also be impossible in programs which run in ROM. The C-compiler makes extensive use of this capability for local variables.

LSL Logical Shift Left
Function and limitations as per ASL.

LSR Logical Shift Right
Function and limitations as per ASR, except here the sign is not shifted in on the left, but a 0.

MOVE
The first operand is transferred to the second.
Variations: *MOVEA, MOVEQ*

MOVEM Move Mulitple Registers
Here an operand can consist of a list of registers. This can be used to place all of the registers on the stack, for instance.
Example: MOVEM.L A0-A6/D0-D7,-(A7)

MOVEP Move Peripheral Data

This specialty is made expressly for the operation of peripheral components. As a general rule, these work only with an 8-bit data bus, and are then connected only to the upper or lower 8 bits of the 68000's data bus. If a word or long word is to be transferred, the bytes must be passed over either the upper or lower byte of the data bus, depending on whether the address is even or odd. The address is then always incremented by two so that the transfer always continues on the same half of the data bus on which it was begun. Corresponding to the purpose of this instruction, one operand is always a data register, and the other is always of type register indirect with offset.

MULS Multiply Signed

Signed multiplication of two operands.

MULU Multiply Unsigned

Multiplication of two operands, ignoring the sign.

NBCD Negate Decimal with Extend

A BCD operand is subjected to the operation 0-operand X.

NEG Negate Binary

The operand is subjected to the treatment 0-operand.
Variations: *NEGX*

NOP No Operation

As the name says, this instruction doesn't do anything.

NOT One's Complement

The operand is inverted.

OR Logical OR

The two operands are combined according to the rule for logical OR.

PEA Push Effective Address

The address itself, not its contents, is placed on the stack.

RESET Reset External Devices

The reset line on the 68000 is bidirectional. Not only can the processor be externally reset, but it can also use this instruction to reset all of the peripheral devices connected to the reset line.
This is a privileged instruction!

ROL Rotate Left
The operand is shifted to the left, whereby the bit shifted out on the left will be shifted back in on the right and the carry flag is affected. Processing widths and shift counter as per ASL.

ROR Rotate Right
As above, but shift from left to right.

ROXL Rotate Left with Extend
As ROL, but the shifted bit is first placed in the X flag, the previous value of which is shifted in on the right.

ROXR Rotate Right with Extend
As above, but reversed shift direction.

RTE Return from Exception
Return from an exception routine to the location at which the exception occurred.

RTS Return from Subroutine
Return from a subroutine to the location at which it was called.

RTR Return and Restore
As above, but the CC register (the one with the flags) is first fetched from the stack (on which it *must* have first been placed, because otherwise execution will not return to the proper address.

SBCD Subtract Decimal with Extend
The first operand is subtracted from the second. Refer to ABCD for information on the data format.

Scc Set Conditionally
The operand (only .B) is set to $FF if the condition is fulfilled. Otherwise it is cleared. Refer to Bcc for the possible condition codes.

STOP
The processor is stopped and can only be called back to life through an external interrupt.
This is a privileged instruction!

SUB Subtract Binary
The first operand is subtracted from the second.

SWAP Swap Register Halves

The two halves of a data register are exchanged with each other.

TAS Test and Set Operand

The operand (only .B) is checked for sign and 0 (affecting the C and N flags). Bit 7 is then set to 1.

TRAP

The applications programmer uses this instruction when he wants to call functions of the operating systems. This instruction generates an exception, which consists of continuing the program at the address determined by the given vector number. See the chapter on the BIOS and XBIOS for the use of this instruction.

TRAPV Trap on Overflow

If the V flag is set, an exception is generated by this instruction, resulting in program execution continuing at the address in vector 7 ($1C).

TST Test

Action like TAS, but the operand is not changed.

UNLK Unlink

This instruction is the counterpart of LINK. The stack pointer (A7) is loaded with the given address register and this is supplied with the last stack entry. In this manner the area reserved with LINK is released.

Addendum to the condition codes: The conditions listed under Bcc are not complete, because the additional conditions do not make sense at that point. But the instructions DBcc and Scc have the additional variations T (DBT, ST) and F (DBF, SF). T stands for true and means that the condition is always fulfilled. F stands for false and is the opposite: the condition is never fulfilled.

DBF can also use the syntax DBRA.

3.9 The BIOS Listing

The situation concerning ST software has changed radically since the Spring of 1985. Nowadays you can find a wealth of programs which are fully supported by GEM, and as a consequence are easy to operate. In addition, many dealers have gone over exclusively to the ST.

One thing is certain: If available software and hardware under development are any indicators, the Atari ST has caught on as an incredibly popular computer.

The following is the commented BIOS listing of the Atari ST. It is patterned after the ROM version of February 1986. The listing includes system initialization, the complete BIOS and XBIOS, as well as the VT52 screen driver. We don't expect any changes to this listing in the near future. Any alterations to the ST that affect this listing will be reflected in later editions of this book (we plan on keeping abreast of any changes, naturally).

The variables in the ROM version lie in the same range (up to $6100) as the diskette version of TOS from February 1986.

If you want to use system routines from TOS in your own programs you should only use the call through the corresponding TRAP. Otherwise, your program won't run with any altered versions of TOS. This applies at the same time to the use of variables which are not contained in the list of system variables.

Otherwise, you can call the BIOS routines as excellent illustrations in 68000 assembly language. If your own routines are to be complex and transparent, you can convert most of them to C compiled code. Then you can recognize most of these routines since they start with `link #n,A6`. `A6` as a base register will communicate with given parameters if there is a positive offset; a negative offset will communicate with the local variables of this routine.

```
*******************************************************    ATARI ST ROM-BIOS
FC0000 601E                 bra      $FC0020               to start of program
FC0002 0100                 dc.b     1,0                   Version 1
FC0004 00FC0020             dc.l     $FC0020               Reset address
FC0008 00FC0000             dc.l     $FC0000               Start of the operating system
FC000C 00006100             dc.l     $6100                 Start of free RAM
FC0010 00FC0020             dc.l     $FC0020               Default shell (reset)
FC0014 00FEFFF4             dc.l     $FEFFF4               Address for GEM magic
FC0018 02061986             dc.l     $02061986             Creation date  2/6/1986
FC001C 0003                 dc.w     3                     Flag for PAL version
FC001E 0C46                 dc.w     $0C46                 Date in DOS format
FC0020 46FC2700             move.w   #$2700,SR             Supervisor mode, IPL 7
FC0024 4E70                 reset                          Reset peripherals
FC0026 0CB9FA52235F00FA0000 cmp.l    #$FA52235F,$FA0000    Diagnostic cartridge inserted ?
FC0030 660A                 bne      $FC003C               no
FC0032 4DFA0008             lea      $FC003C(PC),A6        Load return address
FC0036 4EF900FA0004         jmp      $FA0004               Jump to cartridge

FC003C 4DFA0006             lea      $FC0044(PC),A6        Load return address
FC0040 60000596             bra      $FC05D8               Memory configuration valid?
FC0044 660A                 bne      $FC0050               no
FC0046 13F900000424FFFF8001 move.b   $424,$FFFF8001        Get memctrl
FC0050 9BCD                 sub.l    A5,A5                 Clear A5
FC0052 0CAD314159260426     cmp.l    #$31415926,$426(A5)   resvalid, resvector valid ?
FC005A 6618                 bne      $FC0074               No
FC005C 202D042A             move.l   $42A(A5),D0           Load resvector
FC0060 4A2D042A             tst.b    $42A(A5)              Test bits 24-31
FC0064 660E                 bne      $FC0074               Set, vector invalid
FC0066 08000000             btst     #0,D0                 Address odd?
FC006A 6608                 bne      $FC0074               Yes, invalid
FC006C 2040                 move.l   D0,A0                 Load address
FC006E 4DFAFFE0             lea      $FC0050(PC),A6        Load return address
```

```
FC0072 4ED0               jmp      (A0)               Jump via vector
FC0074 41F9FFFF8800       lea      $FFFF8800,A0       Address of the PSG
FC007A 10BC0007           move.b   #7,(A0)            Port A and B
FC007E 117C00C00002       move.b   #$C0,2(A0)         To output
FC0084 10BC000E           move.b   #$E,(A0)           Select port A
FC0088 117C00070002       move.b   #7,2(A0)           Deselect floppies
FC008E 083A0000FF8B       btst     #0,$FC001B(PC)     Pal version ? (must be $FC001D)
FC0094 6710               beq      $FC00A6            No
FC0096 4DFA0006           lea      $FC009E(PC),A6     Load return address
FC009A 60000C48           bra      $FC0CE4
FC009E 13FC0002FFFF820A   move.b   #2,$FFFF820A       Sync mode to 50 Hz Pal
FC00A6 43F9FFFF8240       lea      $FFFF8240,A1       Address of the color palette
FC00AC 303C000F           move.w   #$F,D0             16 colors
FC00B0 41FA054C           lea      $FC05FE(PC),A0     Address of the color table
FC00B4 32D8               move.w   (A0)+,(A1)+        Copy color in palette
FC00B6 51C8FFFC           dbra     D0,$FC00B4         Next color
FC00BA 13FC0001FFFF8201   move.b   #1,$FFFF8201       dbaseh
FC00C2 13FC0000FFFF8203   move.b   #0,$FFFF8203       dbasel, video address to $10000
FC00CA 9BCD               sub.l    A5,A5              Clear A5
FC00CC 1C2D0424           move.b   $424(A5),D6        memctrl
FC00D0 2A2D042E           move.l   $42E(A5),D5        phystop
FC00D4 4DFA0006           lea      $FC00DC(PC),A6     Load return address
FC00D8 600004FE           bra      $FC05D8            Memory configuration valid?
FC00DC 670000E4           beq      $FC01C2            Yes
FC00E0 4246               clr.w    D6                 Start value for memory controller
FC00E2 13FC000AFFFF8001   move.b   #$A,$FFFF8001      Memory controller to 2 * 2 MB
FC00EA 307C0008           move.w   #8,A0              Start address for memory test
FC00EE 43F900200008       lea      $200008,A1         A1 points to second bank
FC00F4 4240               clr.w    D0                 Clear bit pattern to be written
FC00F6 30C0               move.w   D0,(A0)+           Write pattern
FC00F8 32C0               move.w   D0,(A1)+           Write to other address range
FC00FA D07CFA54           add.w    #$FA54,D0          Next bit pattern
```

```
FC00FE B1FC00000200     cmp.l    #$200,A0           End address reached?
FC0104 66F0             bne      $FC00F6            No
FC0106 223C00200000     move.l   #$200000,D1        D1 equals second bacnk
FC010C E44E             lsr.w    #2,D6
FC010E 307C0208         move.w   #$208,A0           Is bit pattern at $208 ?
FC0112 4BFA0006         lea      $FC011A(PC),A5     Load return address
FC0116 600004AA         bra      $FC05C2            Memory test
FC011A 6720             beq      $FC013C            OK, 128 K
FC011C 307C0408         move.w   #$408,A0           At $408 ?
FC0120 4BFA0006         lea      $FC0128(PC),A5     Load return address
FC0124 6000049C         bra      $FC05C2            Memory test
FC0128 6710             beq      $FC013A            OK, 512 K
FC012A 307C0008         move.w   #$8,A0             At $8
FC012E 4BFA0006         lea      $FC0136(PC),A5     Load return address
FC0132 6000048E         bra      $FC05C2            Memory test
FC0136 6604             bne      $FC013C            Nothing in this bank
FC0138 5846             addq.w   #4,D6
FC013A 5846             addq.w   #4,D6              Configuration byte to 2 MB
FC013C 92BC00200000     sub.l    #$200000,D1        Next bank
FC0142 67C8             beq      $FC010C            Test for first bank
FC0144 13C6FFFF8001     move.b   D6,$FFFF8001       Program memory controller
FC014A 287900000008     move.l   $8,A4              Save Bus Error vector
FC0150 41FA0036         lea      $FC0188(PC),A0     Address of new Bus-Error routine
FC0154 23C800000008     move.l   A0,$8              Set
FC015A 363CFB55         move.w   #$FB55,D3          Start bit pattern
FC015E 2E3C00020000     move.l   #$20000,D7         Start address is 128 K
FC0164 2047             move.l   D7,A0              Save current
FC0166 2248             move.l   A0,A1              address
FC0168 3400             move.w   D0,D2
FC016A 722A             moveq.l  #42,D1             43 words
FC016C 3302             move.w   D2,-(A1)           Write bit pattern in RAM
FC016E D443             add.w    D3,D2              Change pattern
```

```
FC0170 51C9FFFA           dbra     D1,$FC016C              Write next bit pattern
FC0174 2248               move.l   A0,A1                   Repeat address
FC0176 722A               moveq.l  #42,D1                  43 words
FC0178 B061               cmp.w    -(A1),D0                Is bit pattern in RAM?
FC017A 660C               bne      $FC0188                 No, terminate test
FC017C 4251               clr.w    (A1)                    Clear RAM
FC017E D043               add.w    D3,D0                   Change bit pattern
FC0180 51C9FFF6           dbra     D1,$FC0178              Test next word
FC0184 D1C7               add.l    D7,A0                   Increment address by 128K
FC0186 60DE               bra      $FC0166                 Continue testing

FC0188 91C7               sub.l    D7,A0                   Address minus 128 K
FC018A 2A08               move.l   A0,D5                   Save
FC018C 23CC00000008       move.l   A4,$8                   Restore old Bus-Error vector
FC0192 2045               move.l   D5,A0                   Highest address for clear
FC0194 283C00000400       move.l   #$400,D4                Lower bound for clear
FC019A 4CFA000F0450       movem.l  $FC05EC(PC),D0-D3       Clear registers D0-D3
FC01A0 48E0F000           movem.l  D0-D3,-(A0)             Clear 16 bytes
FC01A4 B1C4               cmp.l    D4,A0                   Lower bound reached?
FC01A6 66F8               bne      $FC01A0                 No, continue
FC01A8 9BCD               sub.l    A5,A5                   Clear A5
FC01AA 1B460424           move.b   D6,$424(A5)             memctrl
FC01AE 2B45042E           move.l   D5,$42E(A5)             Highest RAM address as phystop
FC01B2 2B7C752019F30420   move.l   #$752019F3,$420(A5)     magic to memvalid
FC01BA 2B7C237698AA043A   move.l   #$237698AA,$43A(A5)     magic to memval2
FC01C2 9BCD               sub.l    A5,A5                   Clear A5
FC01C4 307C093A           move.w   #$93A,A0                End of the system variables
FC01C8 227C00010000       move.l   #$10000,A1              to current video address
FC01CE 7000               moveq.l  #0,D0
FC01D0 30C0               move.w   D0,(A0)+                Clear memory
FC01D2 B3C8               cmp.l    A0,A1                   End address reached?
FC01D4 66FA               bne      $FC01D0                 No
```

```
FC01D6 206D042E              move.l  $42E(A5),A0            phystop
FC01DA 91FC00008000          sub.l   #$8000,A0              minus 32 K
FC01E0 2B48044E              move.l  A0,$44E(A5)            equals _v_bs_ad
FC01E4 13ED044FFFFF8201      move.b  $44F(A5),$FFFF8201     dbaseh
FC01EC 13ED0450FFFF8203      move.b  $450(A5),$FFFF8203     dbasel
FC01F4 323C07FF              move.w  #$7FF,D1               32 K
FC01F8 20C0                  move.l  D0,(A0)+
FC01FA 20C0                  move.l  D0,(A0)+               Clear screen
FC01FC 20C0                  move.l  D0,(A0)+
FC01FE 20C0                  move.l  D0,(A0)+
FC0200 51C9FFF6              dbra    D1,$FC01F8             Next 16 bytes
FC0204 207AFE0E              move.l  $FC0014(PC),A0         Address os_magic
FC0208 0C9087654321          cmp.l   #$87654321,(A0)        magic present ?
FC020E 6704                  beq     $FC0214                Yes
FC0210 41FAFDF6              lea     $FC0008(PC),A0         Else use system addresses
FC0214 23E80004000004FA      move.l  4(A0),$4FA             end_os
FC021C 23E80008000004FE      move.l  8(A0),$4FE             exec_os
FC0224 2B7C00FC0D60046A      move.l  #$FC0D60,$46A(A5)      hdv_init
FC022C 2B7C00FC10D20476      move.l  #$FC10D2,$476(A5)      hdv_rw
FC0234 2B7C00FC0DE60472      move.l  #$FC0DE6,$472(A5)      hdv_bpb
FC023C 2B7C00FC0F96047E      move.l  #$FC0F96,$47E(A5)      hdv_mediach
FC0244 2B7C00FC137C047A      move.l  #$FC137C,$47A(A5)      hdv_boot
FC024C 2B7C00FC1F340506      move.l  #$FC1F34,$506(A5)      prt_stat
FC0254 2B7C00FC1EA0050A      move.l  #$FC1EA0,$50A(A5)      prt_vec
FC025C 2B7C00FC1F6E050E      move.l  #$FC1F6E,$50E(A5)      aux_stat
FC0264 2B7C00FC1F860512      move.l  #$FC1F86,$512(A5)      aux_vec
FC026C 2B7C00FC0C2C0502      move.l  #$FC0C2C,$502(A5)      dump_vec
FC0274 2B6D044E0436          move.l  $44E(A5),$436(A5)      _v_bs_ad to _memtop
FC027A 2B6D04FA0432          move.l  $4FA(A5),$432(A5)      end_os to _membot
FC0280 4FF900004DB8          lea     $4DB8,A7               Initialize system stack pointer
FC0286 3B7C00080454          move.w  #8,$454(A5)            nvbls
FC028C 50ED0444              st      $444(A5)               _fverify
```

```
FC0290 3B7C00030440         move.w  #3,$440(A5)          seek rate to 3 ms
FC0296 2B7C0000167A04C6     move.l  #$167A,$4C6(A5)      _dskbufp
FC029E 3B7CFFFF04EE         move.w  #-1,$4EE(A5)         clear _dumpflg
FC02A4 2B7C00FC000004F2     move.l  #$FC0000,$4F2(A5)    _sysbase to ROM start
FC02AC 2B7C0000093A04A2     move.l  #$93A,$4A2(A5)       savptr for BIOS
FC02B4 2B7C00FC05C0046E     move.l  #$FC05C0,$46E(A5)    swv_vec for monitor change to rts
FC02BC 47FA0466             lea     $FC0724(PC),A3       Address rte
FC02C0 49FA02FE             lea     $FC05C0(PC),A4       Address rts
FC02C4 0CB9FA52235F00FA0000 cmp.l   #$FA52235F,$FA0000   Diagnostic cartridge inserted ?
FC02CE 6726                 beq     $FC02F6              Yes
FC02D0 43FA0748             lea     $FC0A1A(PC),A1       Indicate address for exception
FC02D4 D3FC02000000         add.l   #$2000000,A1         Vector number in bits 24-31 to 2
FC02DA 41F900000008         lea     $8,A0                Start with Bus Error
FC02E0 303C003D             move.w  #$3D,D0              62 vectors
FC02E4 20C9                 move.l  A1,(A0)+             Set vector
FC02E6 D3FC01000000         add.l   #$1000000,A1         Increment vector number
FC02EC 51C8FFF6             dbra    D0,$FC02E4           Initialize next exception vector
FC02F0 23CB00000014         move.l  A3,$14               'Division by Zero' to rte
FC02F6 2B7C00FC06340070     move.l  #$FC0634,112(A5)     VBL interrupt, IPL 4
FC02FE 2B7C00FC061E0068     move.l  #$FC061E,104(A5)     HBL interrupt, IPL 2
FC0306 2B4B0088             move.l  A3,136(A5)           TRAP #2 to rte
FC030A 2B7C00FC074E00B4     move.l  #$FC074E,180(A5)     TRAP #13 vector
FC0312 2B7C00FC074800B8     move.l  #$FC0748,184(A5)     TRAP #14 vector
FC031A 2B7C00FC9CA20028     move.l  #$FC9CA2,40(A5)      LINE A vector
FC0322 2B4C0400             move.l  A4,$400(A5)          etv_timer to rts
FC0326 2B7C00FC07440404     move.l  #$FC0744,$404(A5)    etv_critic vector
FC032E 2B4C0408             move.l  A4,$408(A5)          etv_term to rts
FC0332 41ED04CE             lea     $4CE(A5),A0          _vbl_list
FC0336 2B480456             move.l  A0,$456(A5)          as pointer to _vblqueue
FC033A 303C0007             move.w  #7,D0                8 entries
FC033E 4298                 clr.l   (A0)+                clear
FC0340 51C8FFFC             dbra    D0,$FC033E           Next entry
```

```
FC0344 61001E6E             bsr     $FC21B4                Initialize mfp
FC0348 7002                 moveq.l #2,D0                  Bit 2
FC034A 6100024A             bsr     $FC0596                cartscan
FC034E 1039FFFF8260         move.b  $FFFF8260,D0           Video resolution
FC0354 C03C0003             and.b   #3,D0                  Isolate bits 0 and 1
FC0358 B03C0003             cmp.b   #3,D0                  Invalid value?
FC035C 6602                 bne     $FC0360                No
FC035E 7002                 moveq.l #2,D0                  Replace with 2 for high resolution
FC0360 13C00000044C         move.b  D0,$44C                sshiftmod
FC0366 1039FFFFFA01         move.b  $FFFFFA01,D0           mfp gpip, monomon
FC036C 6B18                 bmi     $FC0386                No monochrome monitor?
FC036E 4DFA0006             lea     $FC0376(PC),A6         No return address
FC0372 60000970             bra     $FC0CE4
FC0376 13FC0002FFFF8260     move.b  #2,$FFFF8260           High resolution
FC037E 13FC00020000044C     move.b  #2,$44C                sshiftmod
FC0386 4EB900FCA7C4         jsr     $FCA7C4                Initialize screen output
FC038C 0C390001000044C      cmp.b   #1,$44C                sshiftmod
FC0394 660A                 bne     $FC03A0                Not medium resolution ?
FC0396 33F9FFFF825EFFFF8246 move.w  $FFFF825E,$FFFF8246    Copy color 15 (black) to color 3
FC03A0 2B7C00FC0020046E     move.l  #$FC0020,$46E(A5)      swv_vec to teset
FC03A8 33FC000100000452     move.w  #1,$452                vblsem
FC03B0 4240                 clr.w   D0                     Bit 0
FC03B2 610001E2             bsr     $FC0596                cartscan
FC03B6 46FC2300             move.w  #$2300,SR              IPL 3
FC03BA 7001                 moveq.l #1,D0                  Bit 1
FC03BC 610001D8             bsr     $FC0596                cartscan
FC03C0 61004798             bsr     $FC4B5A                Initialize DOS
FC03C4 3F3900FC001E         move.w  $FC001E,-(A7)          Creation date in DOS format
FC03CA 3F3C002B             move.w  #$2B,-(A7)             Set date
FC03CE 4E41                 trap    #1                     GEMDOS
FC03D0 584F                 addq.w  #4,A7                  Correct stack pointer
FC03D2 610000B8             bsr     $FC048C                Boot from floppy
```

```
FC03D6 610000D0           bsr      $FC04A8           Boot from DMA bus
FC03DA 61000944           bsr      $FC0D20           Execute reset-resident programs
FC03DE 4A7900000482       tst.w    $482              _cmdload ?
FC03E4 6718               beq      $FC03FE           No
FC03E6 61004194           bsr      $FC457C           Turn cursor on
FC03EA 61000728           bsr      $FC0B14           autoexec, execute programs in AUTO folder
FC03EE 487A0099           pea      $FC0489(PC)       Null name
FC03F2 487A0095           pea      $FC0489(PC)       Null name
FC03F6 487A007E           pea      $FC0476(PC)       'COMMAND.PRG'
FC03FA 4267               clr.w    -(A7)             Load and start program
FC03FC 605C               bra      $FC045A           Load to program
FC03FE 61000714           bsr      $FC0B14           autoexec, execute programs in AUTO folder
FC0402 41FA0066           lea      $FC046A(PC),A0    'PATH='
FC0406 327C0840           move.w   #$840,A1          Address for environment
FC040A 0C100023           cmp.b    #35,(A0)          '#', place holder for drive?
FC040E 6602               bne      $FC0412           No
FC0410 2449               move.l   A1,A2             Save address
FC0412 12D8               move.b   (A0)+,(A1)+       Copy filenames
FC0414 6AF4               bpl      $FC040A           Next byte
FC0416 103900000446       move.b   $446,D0           _bootdev
FC041C D03C0041           add.b    #$41,D0           'A'
FC0420 1480               move.b   D0,(A2)           Insert drive number
FC0422 487900000840       pea      $840              environment
FC0428 487900FC0489       pea      $FC0489           Null name
FC042E 487A0059           pea      $FC0489(PC)       Null name
FC0432 3F3C0005           move.w   #5,-(A7)          Create base page
FC0436 3F3C004B           move.w   #$4B,-(A7)        exec
FC043A 4E41               trap     #1                GEMDOS
FC043C DEFC000E           add.w    #$E,A7            Correct stack pointer
FC0440 2040               move.l   D0,A0             Address of the base page
FC0442 2179000004FE0008   move.l   $4FE,8(A0)        exec_os, start address AES and Desktop
FC044A 487900000840       pea      $840              environment
```

```
FC0450 2F08                move.l  A0,-(A7)          Address of the base page
FC0452 487A0035            pea     $FC0489(PC)       Null name
FC0456 3F3C0004            move.w  #4,-(A7)          Start program
FC045A 3F3C004B            move.w  #$4B,-(A7)        exec
FC045E 4E41                trap    #1                GEMDOS
FC0460 DEFC000E            add.w   #$E,A7            Correct stack pointer
FC0464 4EF900FC0020        jmp     $FC0020           it return to reset
FC046A 504154483D00        dc.b    'PATH=',0
FC0470 233A5C0000FF        dc.b    '#:\',0,0,$FF
FC0476 434F4D4D414E442E    dc.b    'COMMAND.PRG',0
FC047E 50524700
FC0482 47454D2E505247      dc.b    'GEM.PRG'
FC0489 000000              dc.b    0,0,0
*************************************************   Boot from floppy
FC048C 7003                moveq.l #3,D0             Bit 3
FC048E 61000106            bsr     $FC0596           cartscan
FC0492 20790000047A        move.l  $47A,A0           hdv_boot
FC0498 4E90                jsr     (A0)              Load boot sector
FC049A 4A40                tst.w   D0                Executable ?
FC049C 6608                bne     $FC04A6           No
FC049E 41F90000167A        lea     $167A,A0          Address of the disk buffer
FC04A4 4E90                jsr     (A0)              Execute boot sector
FC04A6 4E75                rts
*************************************************   dmaboot, load boot sector from DMA bus
FC04A8 7E00                moveq.l #0,D7             Begin with device 0
FC04AA 612A                bsr     $FC04D6           dmaread, load boot sector
FC04AC 6620                bne     $FC04CE           Error, test next device
FC04AE 2079000004C6        move.l  $4C6,A0           _dskbufp
FC04B4 323C00FF            move.w  #$FF,D1           $100 words
FC04B8 7000                moveq.l #0,D0             Clear sum
FC04BA D058                add.w   (A0)+,D0          Generate checksum
FC04BC 51C9FFFC            dbra    D1,$FC04BA        Next word
```

```
FC04C0 B07C1234             cmp.w     #$1234,D0          Executable sector?
FC04C4 6608                 bne       $FC04CE            No
FC04C6 2079000004C6         move.l    $4C6,A0            _dskbufp
FC04CC 4E90                 jsr       (A0)               Execute boot sector
FC04CE DE3C0020             add.b     #$20,D7            Next device number
FC04D2 66D6                 bne       $FC04AA            All 8 devices?
FC04D4 4E75                 rts
******************************************************** dmaread, load boot sector from DMA bus
FC04D6 4DF9FFFF8606         lea       $FFFF8606,A6       DMA control register
FC04DC 4BF9FFFF8604         lea       $FFFF8604,A5       DMA data register
FC04E2 50F90000043E         st        $43E               set flock
FC04E8 2F39000004C6         move.l    $4C6,-(A7)         _dskbufp
FC04EE 13EF0003FFFF860D     move.b    3(A7),$FFFF860D
FC04F6 13EF0002FFFF860B     move.b    2(A7),$FFFF860B    Set DMA address
FC04FE 13EF0001FFFF8609     move.b    1(A7),$FFFF8609
FC0506 584F                 addq.w    #4,A7              Correct stack pointer
FC0508 3CBC0098             move.w    #$98,(A6)          Toggle R/W,
FC050C 3CBC0198             move.w    #$198,(A6)         to allow READ
FC0510 3CBC0098             move.w    #$98,(A6)
FC0514 3ABC0001             move.w    #1,(A5)            sector-count register to 1
FC0518 3CBC0088             move.w    #$88,(A6)          Select DMA bus
FC051C 1007                 move.b    D7,D0              Device number << 5
FC051E 803C0008             or.b      #8,D0              OR with read command
FC0522 4840                 swap      D0
FC0524 303C0088             move.w    #$88,D0
FC0528 614C                 bsr       $FC0576            Output byte to DMA bus
FC052A 662A                 bne       $FC0556            timeout, terminate
FC052C 7C03                 moveq.l   #3,D6              Counter to 4
FC052E 41FA0036             lea       $FC0566(PC),A0     Pointer to command word table
FC0532 2018                 move.l    (A0)+,D0           Get command
FC0534 6140                 bsr       $FC0576            Output on DMA bus
FC0536 661E                 bne       $FC0556            timeout, terminate
```

```
FC0538 51CEFFF8          dbra     D6,$FC0532         Next command
FC053C 2ABC0000000A      move.l   #$A,(A5)           Send byte 6 (last byte)
FC0542 323C0190          move.w   #$190,D1
FC0546 6132              bsr      $FC057A            Write byte
FC0548 660C              bne      $FC0556            timeout, terminate
FC054A 3CBC008A          move.w   #$8A,(A6)          Select status register
FC054E 3015              move.w   (A5),D0            Read status
FC0550 C07C00FF          and.w    #$FF,D0            Isolate bits 0-7
FC0554 6702              beq      $FC0558            ok
FC0556 70FF              moveq.l  #-1,D0             Return code for error
FC0558 3CBC0080          move.w   #$80,(A6)          DMA chip back to floppy operation
FC055C 4A00              tst.b    D0                 Set flags
FC055E 51F90000043E      sf       $43E               Clear flock
FC0564 4E75              rts

*****************************************************  Command words for DMA chip
FC0566 0000008A          dc.l     $0000008A
FC056A 0000008A          dc.l     $0000008A
FC056E 0000008A          dc.l     $0000008A
FC0572 0001008A          dc.l     $0001008A

*****************************************************  wcbyte, output byte to DMA bus
FC0576 2A80              move.l   D0,(A5)            Output byte
FC0578 720A              moveq.l  #10,D1             Wait 1/20 second
FC057A D2B9000004BA      add.l    $4BA,D1            _hz_200
FC0580 08390005FFFFFA01  btst     #5,$FFFFFA01       mfp gpip, command processed?
FC0588 670A              beq      $FC0594            Yes
FC058A B2B9000004BA      cmp.l    $4BA,D1            _hz_200, time run out?
FC0590 66EE              bne      $FC0580            No, keep waiting
FC0592 72FF              moveq.l  #-1,D1             Return code for error
FC0594 4E75              rts
```

```
*******************************************************   cartscan,  test cartridge
FC0596 41F900FA0000        lea      $FA0000,A0             Address of the cartridge
FC059C 0C98ABCDEF42        cmp.l    #$ABCDEF42,(A0)+       User cartridge ?
FC05A2 661A                bne      $FC05BE                No
FC05A4 01280004            btst     D0,4(A0)               Corresponding bit set?
FC05A8 670E                beq      $FC05B8                No
FC05AA 48E7FFFE            movem.l  D0-D7/A0-A6,-(A7)      Save registers
FC05AE 20680004            move.l   4(A0),A0               Get address of the routine
FC05B2 4E90                jsr      (A0)                   and execute
FC05B4 4CDF7FFF            movem.l  (A7)+,D0-D7/A0-A6      Save registers
FC05B8 4A90                tst.l    (A0)                   Further use?
FC05BA 2050                move.l   (A0),A0                Get address
FC05BC 66E6                bne      $FC05A4                Yes, keep testing
FC05BE 4E75                rts

*******************************************************
FC05C0 4E75                rts                             rts for dummy routines

*******************************************************   Memory test
FC05C2 D1C1                add.l    D1,A0                  Start address
FC05C4 4240                clr.w    D0                     Clear bit pattern
FC05C6 43E801F8            lea      $1F8(A0),A1            End address
FC05CA B058                cmp.w    (A0)+,D0               Test for bit pattern
FC05CC 6608                bne      $FC05D6                Not equal, error
FC05CE D07CFA54            add.w    #$FA54,D0              Next bit pattern
FC05D2 B3C8                cmp.l    A0,A1                  End address reached?
FC05D4 66F4                bne      $FC05CA                No
FC05D6 4ED5                jmp      (A5)                   Back to call

*******************************************************   Memory configuration valid?
FC05D8 9BCD                sub.l    A5,A5                  Clear A5
FC05DA 0CAD752019F30420    cmp.l    #$752019F3,$420(A5)    magic in memvalid ?
```

```
FC05E2 6608              bne     $FC05EC              No
FC05E4 0CAD237698AA043A  cmp.l   #$237698AA,$43A(A5)  magic in memval2 ?
FC05EC 4ED6              jmp     (A6)                 Back to call

*************************************************     Zero-bytes to clear
FC05EE 00000000          dc.l    0
FC05F2 00000000          dc.l    0
FC05F6 00000000          dc.l    0
FC05FA 00000000          dc.l    0

*************************************************     Standard color palette
FC05FE 0777070000700770  dc.w    $777,$700,$070,$770  White, red, green, yellow
FC0606 0007070700770555  dc.w    $007,$707,$077,$555  blue, magenta, cyan, light gray
FC060E 0333073303730773  dc.w    $333,$733,$373,$773  gray, lt. red, lt. green, lt. yellow
FC0616 0337073703770000  dc.w    $337,$737,$377,$000  lt. blue, lt. magenta, lt. cyan, black

*************************************************     HBL interrupt
FC061E 3F00              move.w  D0,-(A7)             Save D0
FC0620 302F0002          move.w  2(A7),D0             Save status from stack
FC0624 C07C0700          and.w   #$700,D0             Isolate IPL mask
FC0628 6606              bne     $FC0630              Not IPL 0 ?
FC062A 006F03000002      or.w    #$300,2(A7)          Else set IPL 3
FC0630 301F              move.w  (A7)+,D0             D0 back again
FC0632 4E73              rte
*************************************************     VBL interrupt
FC0634 52B900000466      addq.l  #1,$466              _frclock
FC063A 537900000452      subq.w  #1,$452              vblsem
FC0640 6B0000DC          bmi     $FC071E              VBl routine disabled?
FC0644 48E7FFFE          movem.l D0-D7/A0-A6,-(A7)    Save registers
FC0648 52B900000462      addq.l  #1,$462              _vbclock
FC064E 9BCD              sub.l   A5,A5                Clear A5
FC0650 1039FFFF8260      move.b  $FFFF8260,D0         Get video resolution
```

```
FC0656 C03C0003          and.b    #3,D0          Isolate bits 0 and 1
FC065A B03C0002          cmp.b    #2,D0          High resolution ?
FC065E 6C18              bge      $FC0678        Yes
FC0660 08390007FFFFFA01  btst     #7,$FFFFFA01   Monochrome monitor connected ?
FC0668 6634              bne      $FC069E        No
FC066A 303C07D0          move.w   #$7D0,D0       Counter
FC066E 51C8FFFE          dbra     D0,$FC066E     Delay loop
FC0672 103C0002          move.b   #2,D0          High resolution
FC0676 6016              bra      $FC068E

FC0678 08390007FFFFFA01  btst     #7,$FFFFFA01   Monochrome monitor connected ?
FC0680 671C              beq      $FC069E        Yes
FC0682 102D044A          move.b   $44A(A5),D0    defshiftmod
FC0686 B03C0002          cmp.b    #2,D0          High resolution ?
FC068A 6D02              blt      $FC068E        No
FC068C 4200              clr.b    D0
FC068E 1B40044C          move.b   D0,$44C(A5)    sshiftmod
FC0692 13C0FFFF8260      move.b   D0,$FFFF8260   shiftmd, select resolution
FC0698 206D046E          move.l   $46E(A5),A0    swv_vec
FC069C 4E90              jsr      (A0)           Default is reset
FC069E 6100401A          bsr      $FC46BA        Flash cursor
FC06A2 9BCD              sub.l    A5,A5          Clear A5
FC06A4 4AAD045A          tst.l    $45A(A5)       colorptr
FC06A8 6718              beq      $FC06C2        Don't load color palette?
FC06AA 206D045A          move.l   $45A(A5),A0    colorptr
FC06AE 43F9FFFF8240      lea      $FFFF8240,A1   Address of the color register
FC06B4 303C000F          move.w   #$F,D0         16 colors
FC06B8 32D8              move.w   (A0)+,(A1)+    copy
FC06BA 51C8FFFC          dbra     D0,$FC06B8     next color
FC06BE 42AD045A          clr.l    $45A(A5)       colorptr
FC06C2 4AAD045E          tst.l    $45E(A5)       screenpt
FC06C6 671A              beq      $FC06E2        Don't change video address?
```

```
FC06C8 2B6D045E044E     move.l  $45E(A5),$44E(A5)    screenpt to _v_bs_ad
FC06CE 202D044E         move.l  $44E(A5),D0          _v_bs_ad
FC06D2 E088             lsr.l   #8,D0                Bits 8-15
FC06D4 13C0FFFF8203     move.b  D0,$FFFF8203         as dbasel
FC06DA E048             lsr.w   #8,D0                Bits 16-23
FC06DC 13C0FFFF8201     move.b  D0,$FFFF8201         as dbaseh
FC06E2 610012CC         bsr     $FC19B0              flopvbl, floppy VBL routine
FC06E6 3E3900000454     move.w  $454,D7              nvbls
FC06EC 6720             beq     $FC070E              VBL list empty?
FC06EE 5387             subq.l  #1,D7                dbra counter
FC06F0 207900000456     move.l  $456,A0              _vblqueue
FC06F6 2258             move.l  (A0)+,A1             Get address of the routine
FC06F8 B3FC00000000     cmp.l   #0,A1                Not used?
FC06FE 670A             beq     $FC070A              To next routine
FC0700 48E70180         movem.l D7/A0,-(A7)          Save registers
FC0704 4E91             jsr     (A1)                 Execute routine
FC0706 4CDF0180         movem.l (A7)+,D7/A0          Restore registers
FC070A 51CFFFEA         dbra    D7,$FC06F6           Next routine
FC070E 9BCD             sub.l   A5,A5                Clear A5
FC0710 4A6D04EE         tst.w   $4EE(A5)             _dumpflg
FC0714 6604             bne     $FC071A              Not set
FC0716 61000502         bsr     $FC0C1A              Execute hardcopy
FC071A 4CDF7FFF         movem.l (A7)+,D0-D7/A0-A6    Restore registers
FC071E 527900000452     addq.w  #1,$452              vblsem
FC0724 4E73             rte

*****************************************************  wvbl, wait for VBL
FC0726 40E7             move.w  SR, -(A7)            Save status
FC0728 027CF8FF         and.w   #$F8FF,SR            IPL 0, enable interrupts
FC072C 203900000466     move.l  $466,D0              _frclock
FC0732 B0B900000466     cmp.l   $466,D0              _frclock not yet incremented?
FC0738 67F8             beq     $FC0732              No, wait
```

```
FC073A 46DF              move.w   (A7)+,SR            Restore status
FC073C 4E75              rts

*****************************************************  Critical error handler
FC073E 2F3900000404      move.l  $404,-(A7)           etv_critic
FC0744 70FF              moveq.l #-1,D0               Default to error
FC0746 4E75              rts                          Execute routine

*******************************************************  TRAP #14
FC0748 41FA0084          lea     $FC07CE(PC),A0       Address of the TRAP #14 routines
FC074C 6004              bra     $FC0752

*****************************************************  TRAP #13
FC074E 41FA004C          lea     $FC079C(PC),A0       Address of the TRAP #13 routines
FC0752 2279000004A2      move.l  $4A2,A1              Load savptr
FC0758 301F              move.w  (A7)+,D0             Status register to D0
FC075A 3300              move.w  D0,-(A1)             Save in save area
FC075C 231F              move.l  (A7)+,-(A1)          Return address in save area
FC075E 48E11F1F          movem.l D3-D7/A3-A7,-(A1)    Register in save area
FC0762 23C9000004A2      move.l  A1,$4A2              Update savptr
FC0768 0800000D          btst    #13,D0               Call from supervisor mode?
FC076C 6602              bne     $FC0770              Yes
FC076E 4E6F              move.l  USP,A7               Else use USP
FC0770 301F              move.w  (A7)+,D0             Get function number from stack
FC0772 B058              cmp.w   (A0)+,D0             Compare with maximum number
FC0774 6C10              bge     $FC0786              Too big, ignore
FC0776 E548              lsl.w   #2,D0                As long index
FC0778 20300000          move.l  0(A0,D0.w),D0        Get address of the routine
FC077C 2040              move.l  D0,A0                To A0
FC077E 6A02              bpl     $FC0782              Direct address
FC0780 2050              move.l  (A0),A0              Else use indirect
FC0782 9BCD              sub.l   A5,A5                Clear A5
```

```
FC0784 4E90              jsr      (A0)              Execute routine
FC0786 2279000004A2      move.l   $4A2,A1           Get savptr
FC078C 4CD9F8F8          movem.l  (A1)+,D3-D7/A3-A7 Restore registers
FC0790 2F19              move.l   (A1)+,-(A7)       Return address on stack
FC0792 3F19              move.w   (A1)+,-(A7)       Status on stack
FC0794 23C9000004A2      move.l   A1,$4A2           Update savptr
FC079A 4E73              rte

********************************************************* Addresses of the TRAP #13 routines
FC079C 000C              dc.w     12                Number of routines
FC079E 00FC0910          dc.l     $FC0910           0, getmpb
FC07A2 00FC0876          dc.l     $FC0876           1, bconstat
FC07A6 00FC087C          dc.l     $FC087C           2, bconin
FC07AA 00FC0888          dc.l     $FC0888           3, bconout
FC07AE 80000476          dc.l     $476+$80000000    4, (indirect) rwabs
FC07B2 00FC093C          dc.l     $FC093C           5, setexec
FC07B6 00FC0954          dc.l     $FC0954           6, tickcal
FC07BA 80000472          dc.l     $472+$80000000    7, (indirect) getbpb
FC07BE 00FC0882          dc.l     $FC0882           8, bcostat
FC07C2 8000047E          dc.l     $47E+$80000000    9, (indirekct) mediach
FC07C6 00FC08F8          dc.l     $FC08F8           10, drvmap
FC07C8 00FC08FE          dc.l     $FC08FE           11, shift

********************************************************* Addresses of the TRAP #14 routines
FC07CE 0028              dc.w     40                Number of routines
FC07D0 00FC2DDC          dc.l     $FC2DDC           0, initmouse
FC07D4 00FC05C0          dc.l     $FC05C0           1, rts
FC07D8 00FC095C          dc.l     $FC095C           2, physbase
FC07DC 00FC0970          dc.l     $FC0970           3, logbase
FC07E0 00FC0976          dc.l     $FC0976           4, getrez
FC07E4 00FC0982          dc.l     $FC0982           5, setscreen
FC07E8 00FC09D0          dc.l     $FC09D0           6, setpalette
```

```
FC07EC 00FC09D8         dc.l    $FC09D8         7, setcolor
FC07F0 00FC159E         dc.l    $FC159E         8, floprd
FC07F4 00FC167C         dc.l    $FC167C         9, flopwr
FC07F8 00FC1734         dc.l    $FC1734         10, flopfmt
FC07FC 00FC0DDC         dc.l    $FC0DDC         11, getdsb
FC0800 00FC1E40         dc.l    $FC1E40         12, midiws
FC0804 00FC240E         dc.l    $FC240E         13, mfpint
FC0808 00FC2732         dc.l    $FC2732         14, iorec
FC080C 00FC275A         dc.l    $FC275A         15, rsconf
FC0810 00FC2EE2         dc.l    $FC2EE2         16, keytrans
FC0814 00FC132C         dc.l    $FC132C         17, rand
FC0818 00FC1414         dc.l    $FC1414         18, protobt
FC081C 00FC18CE         dc.l    $FC18CE         19, flopver
FC0820 00FC0C1A         dc.l    $FC0C1A         20, dumpit
FC0824 00FC46F2         dc.l    $FC46F2         21, cursconf
FC0828 00FC1D76         dc.l    $FC1D76         22, settime
FC082C 00FC1D5C         dc.l    $FC1D5C         23, gettime
FC0830 00FC2F0E         dc.l    $FC2F0E         24, bioskeys
FC0834 00FC1FBE         dc.l    $FC1FBE         25, ikbdws
FC0838 00FC2438         dc.l    $FC2438         26, jdisint
FC083C 00FC2472         dc.l    $FC2472         27, jenabint
FC0840 00FC2D4C         dc.l    $FC2D4C         28, giaccess
FC0844 00FC2DB6         dc.l    $FC2DB6         29, offgibit
FC0848 00FC2D90         dc.l    $FC2D90         30, ongibit
FC084C 00FC2EA6         dc.l    $FC2EA6         31, xbtimer
FC0850 00FC2F28         dc.l    $FC2F28         32, dosound
FC0854 00FC2F3C         dc.l    $FC2F3C         33, setprt
FC0858 00FC2F70         dc.l    $FC2F70         34, ikbdvecs
FC085C 00FC2F4E         dc.l    $FC2F4E         35, kbrate
FC0860 00FC30AE         dc.l    $FC30AE         36, prtblk
FC0864 00FC0726         dc.l    $FC0726         37, wvbl
FC0868 00FC0870         dc.l    $FC0870         38, supexec
```

```
FC086C 00FC09FE          dc.l    $FC09FE            39, puntaes

*******************************************************  supexec
FC0870 206F0004          move.l  4(A7),A0           Get address
FC0874 4ED0              jmp     (A0)               Execute routine in the supervisor mode

*******************************************************  bconstat, get input status
FC0876 41FA0020          lea     $FC0898(PC),A0     Status table
FC087A 6010              bra     $FC088C

*******************************************************  bconin, input
FC087C 41FA0032          lea     $FC08B0(PC),A0     Input table
FC0880 600A              bra     $FC088C

*******************************************************  bcostat, get output status
FC0882 41FA0044          lea     $FC08C8(PC),A0     Status table
FC0886 6004              bra     $FC088C

*******************************************************  bconout, output
FC0888 41FA0056          lea     $FC08E0(PC),A0     Output table
FC088C 302F0004          move.w  4(A7),D0           Device number
FC0890 E548              lsl.w   #2,D0              times 4
FC0892 20700000          move.l  0(A0,D0.w),A0      Get address of the routine
FC0896 4ED0              jmp     (A0)               Execute routine

*******************************************************  Input status
FC0898 00FC05C0          dc.l    $FC05C0            rts
FC089C 00FC1F48          dc.l    $FC1F48            RS 232 status
FC08A0 00FC1FD2          dc.l    $FC1FD2            Console status
FC08A4 00FC1E54          dc.l    $FC1E54            MIDI status
FC08A8 00FC05C0          dc.l    $FC05C0            rts
FC08AC 00FC05C0          dc.l    $FC05C0            rts
```

```
*******************************************************   Input
FC08B0 00FC1F14           dc.l     $FC1F14                Parallel port
FC08B4 00FC1F5E           dc.l     $FC1F5E                RS 232 input
FC08B8 00FC1FE8           dc.l     $FC1FE8                Console input
FC08BC 00FC1E70           dc.l     $FC1E70                MIDI input
FC08C0 00FC05C0           dc.l     $FC05C0                rts
FC08C4 00FC05C0           dc.l     $FC05C0                rts

*******************************************************   Output status
FC08C8 00FC1F34           dc.l     $FC1F34                Centronics status
FC08CC 00FC1F6E           dc.l     $FC1F6E                RS 232 status
FC08D0 00FC2018           dc.l     $FC2018                Console status
FC08D4 00FC1F92           dc.l     $FC1F92                MIDI status
FC08D8 00FC1E14           dc.l     $FC1E14                IKBD status
FC08DC 00FC05C0           dc.l     $FC05C0                rts

*******************************************************   Output
FC08E0 00FC1EA0           dc.l     $FC1EA0                Centronics output
FC08E4 00FC1F86           dc.l     $FC1F86                RS 232 output
FC08E8 00FC41AC           dc.l     $FC41AC                Console output
FC08EC 00FC1E26           dc.l     $FC1E26                MIDI output
FC08F0 00FC1FA4           dc.l     $FC1FA4                IKBD output
FC08F4 00FC41A0           dc.l     $FC41A0                ASCII output

*******************************************************   drvmap, active drives
FC08F8 202D04C2           move.l   $4C2(A5),D0            _drvbits
FC08FC 4E75               rts        ¿nl¡¿a3¡
*******************************************************   Shift, keyboard status
FC08FE 7000               moveq.l  #0,D0
FC0900 102D0E1B           move.b   $E1B(A5),D0            Shift status
FC0904 322F0004           move.w   4(A7),D1               new shift status
```

```
FC0908 6B04              bmi      $FC090E              -1, not set
FC090A 1B410E1B          move.b   D1,$E1B(A5)          Use new status
FC090E 4E75              rts

*******************************************************  getmpb, Memory Parameter Block
FC0910 206F0004          move.l   4(A7),A0             Address of the mpb
FC0914 43ED048E          lea      $48E(A5),A1          themd, Memory Descriptor
FC0918 2089              move.l   A1,(A0)              mp_mfl = address of the MD
FC091A 42A80004          clr.l    4(A0)                mp_mal = zero
FC091E 21490008          move.l   A1,8(A0)             mp_rover = address of the MD
FC0922 4291              clr.l    (A1)                 clear m_link
FC0924 236D04320004      move.l   $432(A5),4(A1)       _membot as m_start
FC092A 202D0436          move.l   $436(A5),D0          _memtop
FC092E 90AD0432          sub.l    $432(A5),D0          minus _membot
FC0932 23400008          move.l   D0,8(A1)             length m_lenght
FC0936 42A9000C          clr.l    12(A1)               m_own = zero
FC093A 4E75              rts       ¿nl¡¿a3¡
*******************************************************  setexc, set exception vector
FC093C 302F0004          move.w   4(A7),D0             Vector number
FC0940 E548              lsl.w    #2,D0                times 4
FC0942 91C8              sub.l    A0,A0                Clear A0
FC0944 41F00000          lea      0(A0,D0.w),A0        Get address of the vector
FC0948 2010              move.l   (A0),D0              Old vector to D0
FC094A 222F0006          move.l   6(A7),D1             New vector
FC094E 6B02              bmi      $FC0952              Negative, don't set
FC0950 2081              move.l   D1,(A0)              Set new vector
FC0952 4E75              rts

*******************************************************  tickcal, timer value in milliseconds
FC0954 4280              clr.l    D0
FC0956 302D0442          move.w   $442(A5),D0          _timer_ms
FC095A 4E75              rts
```

```
********************************************************   physbase, physical video address
FC095C 7000                moveq.l #0,D0
FC095E 1039FFFF8201        move.b  $FFFF8201,D0          dbaseh
FC0964 E148                lsl.w   #8,D0
FC0966 1039FFFF8203        move.b  $FFFF8203,D0          dbasel
FC096C E188                lsl.l   #8,D0                 Result in D0
FC096E 4E75                rts

********************************************************   logbase, logical video address
FC0970 202D044E            move.l  $44E(A5),D0           _v_bs_ad
FC0974 4E75                rts

********************************************************   getrez, get video resolution
FC0976 7000                moveq.l #0,D0
FC0978 102D8260            move.b  $FFFF8260(A5),D0      sshiftmd
FC097C C03C0003            and.b   #3,D0                 Isolate bits 0 and 1
FC0980 4E75                rts

********************************************************   setscreen, set screen address
FC0982 4AAF0004            tst.l   4(A7)                 Logical address
FC0986 6B06                bmi     $FC098E               Don't set?
FC0988 2B6F0004044E        move.l  4(A7),$44E(A5)        _v_bs_ad
FC098E 4AAF0008            tst.l   8(A7)                 physical address
FC0992 6B10                bmi     $FC09A4               Don't set?
FC0994 13EF0009FFFF8201    move.b  9(A7),$FFFF8201       dbaseh
FC099C 13EF000AFFFF8203    move.b  10(A7),$FFFF8203      dbasel
FC09A4 4A6F000C            tst.w   12(A7)                Video resolution
FC09A8 6B24                bmi     $FC09CE               don't set
FC09AA 1B6F000D044C        move.b  13(A7),$44C(A5)       sshiftmod
FC09B0 6100FD74            bsr     $FC0726               wvbl, wait for VBL
FC09B4 13ED044CFFFF8260    move.b  $44C(A5),$FFFF8260    sshiftmod to shiftmd
```

```
FC09BC 426D0452            clr.w   $452(A5)             vblsem, VBL disabled
FC09C0 4EB900FCA7C4        jsr     $FCA7C4              Initialize screen output
FC09C6 33FC000100000452    move.w  #1,$452              vblsem, enable VBL again
FC09CE 4E75                rts

*************************************************       setpalette, load new color palette
FC09D0 2B6F0004045A        move.l  4(A7),$45A(A5)       colorptr, execution in VBL
FC09D6 4E75                rts

*************************************************       setcolor, set single color
FC09D8 322F0004            move.w  4(A7),D1             Color number
FC09DC D241                add.w   D1,D1                times 2
FC09DE C27C001F            and.w   #$1F,D1              Limit to valid numbers
FC09E2 41F9FFFF8240        lea     $FFFF8240,A0         Address of color palette
FC09E8 30301000            move.w  0(A0,D1.w),D0        Get color
FC09EC C07C0777            and.w   #$777,D0             Isolate RGB bits
FC09F0 4A6F0006            tst.w   6(A7)                New color
FC09F4 6B06                bmi     $FC09FC              negative ?
FC09F6 31AF00061000        move.w  6(A7),0(A0,D1.w)     Set color
FC09FC 4E75                rts

*************************************************       puntaes, clear AES and restart
FC09FE 207AF614            move.l  $FC0014(PC),A0       Address os_magic
FC0A02 0C9087654321        cmp.l   #$87654321,(A0)      magic ?
FC0A08 660E                bne     $FC0A18              No, AES already disabled
FC0A0A B1F90000042E        cmp.l   $42E,A0              phystop, AES in ROM ?
FC0A10 6C06                bge     $FC0A18              Yes, nothing to do
FC0A12 4290                clr.l   (A0)                 clear magic
FC0A14 6000F60A            bra     $FC0020              to reset
FC0A18 4E75                rts
```

```
*****************************************************   term, end program after exception
FC0A1A 6102                bsr     $FC0A1E              PC on stack
FC0A1C 4E71                nop
FC0A1E 23DF000003C4        move.l  (A7)+,$3C4           Save PC including vector number
FC0A24 48F9FFFF00000384    movem.l D0-D7/A0-A7,$384     Save registers
FC0A2C 4E68                move.l  USP,A0               USP
FC0A2E 23C8000003C8        move.l  A0,$3C8              save
FC0A34 700F                moveq.l #15,D0               16 words
FC0A36 41F9000003CC        lea     $3CC,A0              Address save area
FC0A3C 224F                move.l  A7,A1                Get stack pointer
FC0A3E 30D9                move.w  (A1)+,(A0)+          Save 16 words from stack
FC0A40 51C8FFFC            dbra    D0,$FC0A3E           Next word
FC0A44 23FC1234567800000380 move.l #$12345678,$380      magic for saved registers
FC0A4E 7200                moveq.l #0,D1
FC0A50 1239000003C4        move.b  $3C4,D1              Vector number to D1
FC0A56 5341                subq.w  #1,D1                in dbra counter
FC0A58 6116                bsr     $FC0A70              Output appropriate number of "bombs"
FC0A5A 23FC0000093A000004A2 move.l #$93A,$4A2           Reset savptr for BIOS
FC0A64 3F3C0001            move.w  #1,-(A7)             Return code for error
FC0A68 42A7                clr.l   -(A7)                term, end program
FC0A6A 4E41                trap    #1                   GEMDOS
FC0A6C 6000F5B2            bra     $FC0020              if return, then reset

*****************************************************   Write "bombs" to screen
FC0A70 1E39FFFF8260        move.b  $FFFF8260,D7         shiftmd, get resolution
FC0A76 CE7C0003            and.w   #3,D7                Isolate significant bits
FC0A7A DE47                add.w   D7,D7                as word pointer
FC0A7C 4280                clr.l   D0
FC0A7E 1039FFFF8201        move.b  $FFFF8201,D0         dbaseh
FC0A84 E148                lsl.w   #8,D0
FC0A86 1039FFFF8203        move.b  $FFFF8203,D0         dbasel
FC0A8C E188                lsl.l   #8,D0
```

```
FC0A8E 2040              move.l  D0,A0                 yields video address
FC0A90 D0FB702C          add.w   $FC0ABE(PC,D7.w),A0   plus offset for screen center
FC0A94 43F900FC0CC4      lea     $FC0CC4,A1            Address of the bit pattern for bombs
FC0A9A 3C3C000F          move.w  #$F,D6                16 raster lines
FC0A9E 3401              move.w  D1,D2
FC0AA0 2448              move.l  A0,A2                 Save pointer to start of line
FC0AA2 3A3B7022          move.w  $FC0AC6(PC,D7.w),D5   Number of words (screen planes)
FC0AA6 30D1              move.w  (A1),(A0)+            Write one raster line
FC0AA8 51CDFFFC          dbra    D5,$FC0AA6            Next screen plane
FC0AAC 51CAFFF4          dbra    D2,$FC0AA2            Next bomb, same raster line
FC0AB0 5449              addq.w  #2,A1                 Next word of the bit pattern
FC0AB2 D4FB701A          add.w   $FC0ACE(PC,D7.w),A2   Plus line length, next screen line
FC0AB6 204A              move.l  A2,A0                 Start of the line
FC0AB8 51CEFFE4          dbra    D6,$FC0A9E            Next raster line
FC0ABC 4E75              rts

*******************************************************  Offset for screen center
FC0ABE 3E80              dc.w    100*160               low resolution
FC0AC0 3E80              dc.w    100*160               medium resolution
FC0AC2 3E80              dc.w    200*80                high resolution
FC0AC4 3E80              dc.w    200*80                high resolution

*******************************************************  Number of screen planes - 1
FC0AC6 0003              dc.w    3                     low resolution
FC0AC8 0001              dc.w    1                     medium resolution
FC0ACA 0000              dc.w    0                     high resolution
FC0ACC 0000              dc.w    0                     high resolution

*******************************************************  Line length in bytes
FC0ACE 00A0              dc.w    160                   low resolution
FC0AD0 00A0              dc.w    160                   medium resolution
FC0AD2 0050              dc.w    80                    high resolution
```

```
FC0AD4 0050                dc.w    80                   high resolution

*******************************************************  fastcopy, copy floppy sector
FC0AD6 206F0004            move.l  4(A7),A0             Source address
FC0ADA 226F0008            move.l  8(A7),A1             Destination address
FC0ADE 303C003F            moveq.l #63,D0               (63+1)*8 = 512 bytes
FC0AE2 12D8                move.b  (A0)+,(A1)+
FC0AE4 12D8                move.b  (A0)+,(A1)+
FC0AE6 12D8                move.b  (A0)+,(A1)+
FC0AE8 12D8                move.b  (A0)+,(A1)+          Copy 8 bytes
FC0AEA 12D8                move.b  (A0)+,(A1)+
FC0AEC 12D8                move.b  (A0)+,(A1)+
FC0AEE 12D8                move.b  (A0)+,(A1)+
FC0AF0 12D8                move.b  (A0)+,(A1)+
FC0AF2 51C8FFEE            dbra    D0,$FC0AE2           Next 8 bytes
FC0AF6 4E75                rts

*******************************************************  hdv_init, initialize drive data
FC0AF8 2F390000046A        move.l  $46A,-(A7)           hdv_init
FC0AFE 4E75                rts                          Execute routine

*******************************************************
FC0B00 5C4155544F5C        dc.b    '\AUTO\'
FC0B06 2A2E50524700        dc.b    '*.PRG',0
FC0B0C 12345678            dc.l    $12345678
FC0B10 9ABCDEF0            dc.l    $9ABCDEF0

*******************************************************  autoexec, execute programs in auto folder
FC0B14 41FAFFEA            lea     $FC0B00(PC),A0       Address of pathname '\AUTO\*.PRG'
FC0B18 43FAFFEC            lea     $FC0B06(PC),A1       Address of filename '*.PRG'
FC0B1C 23DF0000093A        move.l  (A7)+,$93A           Save return address
FC0B22 9BCD                sub.l   A5,A5                Clear A5
```

```
FC0B24 2B48093E          move.l  A0,$93E(A5)        pathname
FC0B28 2B490942          move.l  A1,$942(A5)        filename
FC0B2C 202D04C2          move.l  $4C2(A5),D0        _drvbits
FC0B30 323900000446      move.w  $446,D1            _bootdev
FC0B36 0300              btst    D1,D0              Drive active ?
FC0B38 6736              beq     $FC0B70            No, done
FC0B3A 41FAF94D          lea     $FC0489(PC),A0     Pointer to null name
FC0B3E 2F08              move.l  A0,-(A7)           Environment
FC0B40 2F08              move.l  A0,-(A7)           Command tail
FC0B42 2F08              move.l  A0,-(A7)           Filler
FC0B44 3F3C0005          move.w  #5,-(A7)           Create base page
FC0B48 3F3C004B          move.w  #$4B,-(A7)         exec
FC0B4C 4E41              trap    #1                 GEMDOS
FC0B4E DEFC0010          add.w   #$10,A7            Correct stack pointer
FC0B52 2040              move.l  D0,A0              Address of the base page
FC0B54 217C00FC0B780008  move.l  #$FC0B78,8(A0)     Start address
FC0B5C 2F0B              move.l  A3,-(A7)           Null string
FC0B5E 2F00              move.l  D0,-(A7)           Base page
FC0B60 2F0B              move.l  A3,-(A7)           Null string
FC0B62 3F3C0004          move.w  #4,-(A7)           Start program
FC0B66 3F3C004B          move.w  #$4B,-(A7)         exec
FC0B6A 4E41              trap    #1                 GEMDOS
FC0B6C DEFC0010          add.w   #$10,A7            Correct stack pointer
FC0B70 2F390000093A      move.l  $93A,-(A7)         Repeat return address
FC0B76 4E75              rts                        Back to call

*******************************************************  Call autoexec program
FC0B78 42A7              clr.l   -(A7)
FC0B7A 3F3C0020          move.w  #$20,-(A7)         super
FC0B7E 4E41              trap    #1                 GEMDOS
FC0B80 5C4F              addq.w  #6,A7              Correct stack pointer
FC0B82 2840              move.l  D0,A4              Saved stack pointer
```

```
FC0B84 2A6F0004         move.l   4(A7),A5          Base page address
FC0B88 4FED0100         lea      $100(A5),A7       Stack pointer to end of base page
FC0B8C 2F3C00000100     move.l   #$100,-(A7)       $100 bytes for base page
FC0B92 2F0D             move.l   A5,-(A7)          Address of the program
FC0B94 4267             clr.w    -(A7)
FC0B96 3F3C004A         move.w   #$4A,-(A7)        setblock, release memory
FC0B9A 4E41             trap     #1                GEMDOS
FC0B9C 5C4F             addq.w   #6,A7             Correct stack pointer
FC0B9E 4A40             tst.w    D0                ok ?
FC0BA0 666A             bne      $FC0C0C           No, terminate
FC0BA2 3F3C0007         move.w   #7,-(A7)          R/O, hidden and system files
FC0BA6 2F390000093E     move.l   $93E,-(A7)        Filename
FC0BAC 3F3C004E         move.w   #$4E,-(A7)        Search first
FC0BB0 7E08             moveq.l  #8,D7             Bytes for stack correction
FC0BB2 487900000946     pea      $946              DMA address for DOS
FC0BB8 3F3C001A         move.w   #$1A,-(A7)        Setdta
FC0BBC 4E41             trap     #1                GEMDOS
FC0BBE 5C4F             addq.w   #6,A7             Correct stack pointer
FC0BC0 4E41             trap     #1                GEMDOS
FC0BC2 DEC7             add.w    D7,A7             Correct stack pointer
FC0BC4 4A40             tst.w    D0                Matching file found?
FC0BC6 6644             bne      $FC0C0C           No
FC0BC8 20790000093E     move.l   $93E,A0           pathname
FC0BCE 247900000942     move.l   $942,A2           filename
FC0BD4 43F900000972     lea      $972,A1           autoname
FC0BDA 12D8             move.b   (A0)+,(A1)+       copy path
FC0BDC B5C8             cmp.l    A0,A2             End of path segment?
FC0BDE 66FA             bne      $FC0BDA           No, keep copying
FC0BE0 41F900000964     lea      $964,A0           Name from DMA buffer
FC0BE6 12D8             move.b   (A0)+,(A1)+       Append to pathname
FC0BE8 66FC             bne      $FC0BE6           End of the name?
FC0BEA 487AF89D         pea      $FC0489(PC)       Null name
```

```
FC0BEE 487AF899          pea      $FC0489(PC)          Null name
FC0BF2 487900000972      pea      $972                 Filename
FC0BF8 4267              clr.w    -(A7)                Load and start program
FC0BFA 3F3C004B          move.w   #$4B,-(A7)           exec
FC0BFE 4E41              trap     #1                   GEMDOS
FC0C00 DEFC0010          add.w    #$10,A7              Correct stack
FC0C04 7E02              moveq.l  #2,D7                Bytes for stack correction
FC0C06 3F3C004F          move.w   #$4F,-(A7)           Search next
FC0C0A 60A6              bra      $FC0BB2              Next program
FC0C0C 4FF900004DB8      lea      $4DB8,A7             Stack pointer to start value
FC0C12 2F390000093A      move.l   $93A,-(A7)           Return address
FC0C18 4E75              rts

*************************************************     scrdmp, screen hardcopy
FC0C1A 207900000502      move.l   $502,A0              dump_vec
FC0C20 4E90              jsr      (A0)                 Execute routine
FC0C22 33FCFFFF000004EE  move.w   #-1,$4EE             clear _dumpflg
FC0C2A 4E75              rts

*************************************************     scrdmp
FC0C2C 9BCD              sub.l    A5,A5                Clear A5
FC0C2E 2B6D044E0992      move.l   $44E(A5),$992(A5)    _v_bs_ad
FC0C34 426D0996          clr.w    $996(A5)             Offset to zero
FC0C38 4240              clr.w    D0
FC0C3A 102D044C          move.b   $44C(A5),D0          sshiftmod
FC0C3E 3B4009A0          move.w   D0,$9A0(A5)          save
FC0C42 D040              add.w    D0,D0                times 2
FC0C44 41FA006A          lea      $FC0CB0(PC),A0       Table for screen resolution
FC0C48 3B7000000998      move.w   0(A0,D0.w),$998(A5)  Get screen width
FC0C4E 3B700006099A      move.w   6(A0,D0.w),$99A(A5)  Get screen height
FC0C54 426D099C          clr.w    $99C(A5)             Left
FC0C58 426D099E          clr.w    $99E(A5)             and right to zero
```

```
FC0C5C 2B7C00FF824009A4     move.l  #$FF8240,$9A4(A5)      Address of color palette
FC0C64 426D09AC             clr.w   $9AC(A5)               Clear mask pointer
FC0C68 322D0E4A             move.w  $E4A(A5),D1            Get printer configuration
FC0C6C E649                 lsr.w   #3,D1                  Draft/quality mode
FC0C6E C27C0001             and.w   #1,D1                  Isolate bit
FC0C72 3B4109A2             move.w  D1,$9A2(A5)            and save
FC0C76 322D0E4A             move.w  $E4A(A5),D1            Printer configuration
FC0C7A 3001                 move.w  D1,D0
FC0C7C E848                 lsr.w   #4,D0                  Parallel/serial
FC0C7E C07C0001             and.w   #1,D0                  Isolate bit
FC0C82 3B4009AA             move.w  D0,$9AA(A5)            and save
FC0C86 C27C0007             and.w   #7,D1                  Isolate printer type
FC0C8A 103B1030             move.b  $FC0CBC(PC,D1.w),D0    Get assignment from table
FC0C8E 33C0000009A8         move.w  D0,$9A8                and save for hardcopy
FC0C94 486D0992             pea     $992(A5)               Address of the parameter block
FC0C98 33FC0001000004EE     move.w  #1,$4EE                _dumpflg to one
FC0CA0 6100240C             bsr     $FC30AE                Execute hardcopy
FC0CA4 33FCFFFF000004EE     move.w  #-1,$4EE               _dumpflg copy
FC0CAC 584F                 addq.w  #4,A7                  Correct stack pointer
FC0CAE 4E75                 rts

*********************************************************  Parameter table for hardcopy
FC0CB0 014002800280         dc.w    320,640,640            Screen widths
FC0CB2 00C800C80190         dc.w    200,200,400            Screen heights

*********************************************************  Printer types (-1 = not implemented )
FC0CBC 00                   dc.b    0                      ATARI B/W dot-matrix
FC0CBD 02                   dc.b    2                      ATARI B/W daisy wheel
FC0CCE 01                   dc.b    1                      ATARI color dot-matrix
FC0CCF FF                   dc.b    -1                     (ATARI color daisy wheel)
FC0CC0 03                   dc.b    3                      Epson B/W dot-matrix
FC0CC1 FF                   dc.b    -1                     (Epson B/W daisy wheel)
```

```
FC0CC2 FF                  dc.b    -1                    (Epson color dot-matrix)
FC0CC3 FF                  dc.b    -1                    (Epson color daisy wheel)

*****************************************************    "Bomb" bit pattern
FC0CC4 0600                dc.b    %0000011000000000
FC0CC6 2900                dc.b    %0010100100000000
FC0CC8 0080                dc.b    %0000000010000000
FC0CCA 4840                dc.b    %0100100001000000
FC0CCC 11F0                dc.b    %0001000111110000
FC0CCE 01F0                dc.b    %0000000111110000
FC0CD0 07FC                dc.b    %0000011111111100
FC0CD2 0FFE                dc.b    %0000111111111110
FC0CD4 0FFE                dc.b    %0000111111111110
FC0CD6 1FFF                dc.b    %0001111111111111
FC0CD8 1FEF                dc.b    %0001111111101111
FC0CDA 0FEE                dc.b    %0000111111101110
FC0CDC 0FDE                dc.b    %0000111111011110
FC0CDE 07FC                dc.b    %0000011111111100
FC0CE0 03F8                dc.b    %0000001111111000
FC0CE2 00E0                dc.b    %0000000011100000

*****************************************************
FC0CE4 41F9FFFFFA21        lea     $FFFFFA21,A0          mfp, Timer B data
FC0CEA 43F9FFFFFA1B        lea     $FFFFFA1B,A1          mfp, Timer B control
FC0CF0 12BC0010            move.b  #$10,(A1)             Timer B output low
FC0CF4 7801                moveq.l #1,D4
FC0CF6 12BC0000            move.b  #0,(A1)               Stop timer B
FC0CFA 10BC00F0            move.b  #$F0,(A0)             Load timer B counter with 240
FC0CFE 13FC0008FFFFFA1B    move.b  #8,$FFFFFA1B          Timer B control, delay mode, /50
FC0D06 1010                move.b  (A0),D0               Load counter value
FC0D08 B004                cmp.b   D4,D0                 Same last value?
FC0D0A 66FA                bne     $FC0D06               No
```

```
FC0D0C 1810              move.b   (A0),D4               Counter value
FC0D0E 363C0267          move.w   #$267,D3              Loop counter to 616
FC0D12 B810              cmp.b    (A0),D4               Counter value equal?
FC0D14 66F6              bne      $FC0D0C               No, read new value
FC0D16 51CBFFFA          dbra     D3,$FC0D12            Next pass
FC0D1A 12BC0010          move.b   #$10,(A1)             Timer B output low
FC0D1E 4ED6              jmp      (A6)                  Back to call

*************************************************      Execute reset resident programs
FC0D20 20790000042E      move.l   $42E,A0               phystop
FC0D26 90FC0200          sub.w    #$200,A0              minus $200
FC0D2A B1FC00000400      cmp.l    #$400,A0              Exception vectors reached?
FC0D30 672C              beq      $FC0D5E               Yes, done
FC0D32 0C9012123456      cmp.l    #$12123456,(A0)       magic ?
FC0D38 66EC              bne      $FC0D26               No
FC0D3A B1E80004          cmp.l    4(A0),A0              Address ?
FC0D3E 66E6              bne      $FC0D26               No
FC0D40 4240              clr.w    D0                    Clear sum
FC0D42 2248              move.l   A0,A1                 Save address
FC0D44 323C00FF          move.w   #$FF,D1               256 words
FC0D48 D059              add.w    (A1)+,D0              sum
FC0D4A 51C9FFFC          dbra     D1,$FC0D48            Next word
FC0D4E B07C5678          cmp.w    #$5678,D0             magic ?
FC0D52 66D2              bne      $FC0D26               No, keep looking
FC0D54 2F08              move.l   A0,-(A7)              Save address
FC0D56 4EA80008          jsr      8(A0)                 Execute routine
FC0D5A 205F              move.l   (A7)+,A0              Restore address
FC0D5C 60C8              bra      $FC0D26               Keep searching
FC0D5E 4E75              rts

*************************************************      hdv_init, initialize drives
FC0D60 4E56FFF0          link     A6,#-16
```

```
FC0D64 23FC0000012C000029B4 move.l  #300,$29B4      maxacctim to 300*20 ms
FC0D6E 4240                 clr.w   D0
FC0D70 33C0000004A6         move.w  D0,$4A6         clear _nflops
FC0D76 33C000005622         move.w  D0,$5622        curflop, current drive
FC0D7C 3D40FFFE             move.w  D0,-2(A6)       Start with drive A
FC0D80 604E                 bra     $FC0DD0         To loop end
FC0D82 207C00004DB8         move.l  #$4DB8,A0       Address of the DSB (Device Status Block)
FC0D88 326EFFFE             move.w  -2(A6),A1       Drive number
FC0D8C D1C9                 add.l   A1,A0           as index
FC0D8E 4210                 clr.b   (A0)            Clear DSB
FC0D90 4257                 clr.w   (A7)
FC0D92 4267                 clr.w   -(A7)
FC0D94 4267                 clr.w   -(A7)
FC0D96 3F2EFFFE             move.w  -2(A6),-(A7)    Drive number
FC0D9A 42A7                 clr.l   -(A7)
FC0D9C 42A7                 clr.l   -(A7)
FC0D9E 4EB900FC1556         jsr     $FC1556         flopini
FC0DA4 DFFC0000000E         add.l   #$E,A7          Correct stack pointer
FC0DAA 3F00                 move.w  D0,-(A7)        Save error code
FC0DAC 306EFFFE             move.w  -2(A6),A0       Drive number
FC0DB0 D1C8                 add.l   A0,A0           times 2
FC0DB2 D1FC000058C0         add.l   #$58C0,A0
FC0DB8 309F                 move.w  (A7)+,(A0)      Error code
FC0DBA 6610                 bne     $FC0DCC         Drive not present?
FC0DBC 5279000004A6         addq.w  #1,$4A6         Increment _nflops
FC0DC2 00B900000003000004C2 or.l    #3,$4C2         _drvbits, drive A and B
FC0DCC 526EFFFE             addq.w  #1,-2(A6)       Increment drive number
FC0DD0 0C6E0002FFFE         cmp.w   #2,-2(A6)       2 drives tested?
FC0DD6 6DAA                 blt     $FC0D82         No
FC0DD8 4E5E                 unlk    A6
FC0DDA 4E75                 rts
```

```
*****************************************************  getdsb
FC0DDC 4E56FFFC            link     A6,#-4
FC0DE0 4280                clr.l    D0              Zero
FC0DE2 4E5E                unlk     A6
FC0DE4 4E75                rts

*****************************************************  getbpb, Get BIOS parameter block
FC0DE6 4E56FFF4            link     A6,#-12
FC0DEA 48E7070C            movem.l  D5-D7/A4-A5,-(A7)  Save registers
FC0DEE 0C6E00020008        cmp.w    #2,8(A6)         Drive number
FC0DF4 6D06                blt      $FC0DFC          < 2, OK
FC0DF6 4280                clr.l    D0               else zero
FC0DF8 60000192            bra      $FC0F8C

FC0DFC 302E0008            move.w   8(A6),D0         Drive number
FC0E00 EB40                asl.w    #5,D0            times 32
FC0E02 48C0                ext.l    D0
FC0E04 2A40                move.l   D0,A5
FC0E06 DBFC00004DCE        add.l    #$4DCE,A5        plus base address
FC0E0C 284D                move.l   A5,A4            save
FC0E0E 3EBC0001            move.w   #1,(A7)          count, read a sector
FC0E12 4267                clr.w    -(A7)            Side 0
FC0E14 4267                clr.w    -(A7)            Track 0
FC0E16 3F3C0001            move.w   #1,-(A7)         Sector 1
FC0E1A 3F2E0008            move.w   8(A6),-(A7)      Drive number
FC0E1E 42A7                clr.l    -(A7)            Filler
FC0E20 2F3C0000167A        move.l   #$167A,-(A7)     Address of disk buffer
FC0E26 4EB900FC159E        jsr      $FC159E          Read sector
FC0E2C DFFC00000010        add.l    #$10,A7          Correct stack pointer
FC0E32 2D40FFF4            move.l   D0,-12(A6)       Error code
FC0E36 4AAEFFF4            tst.l    -12(A6)          test
FC0E3A 6C16                bge      $FC0E52          OK ?
```

```
FC0E3C 3EAE0008        move.w   8(A6),(A7)       Drive number
FC0E40 202EFFF4        move.l   -12(A6),D0       Error code
FC0E44 3F00            move.w   D0,-(A7)         as parameter
FC0E46 4EB900FC073E    jsr      $FC073E          critical error handler
FC0E4C 548F            addq.l   #2,A7            Correct stack pointer
FC0E4E 2D40FFF4        move.l   D0,-12(A6)       Save error code
FC0E52 202EFFF4        move.l   -12(A6),D0       test
FC0E56 B0BC00010000    cmp.l    #$10000,D0       Retry ?
FC0E5C 67B0            beq      $FC0E0E          Yes, try again
FC0E5E 4AAEFFF4        tst.l    -12(A6)          Test error code
FC0E62 6C06            bge      $FC0E6A          OK ?
FC0E64 4280            clr.l    D0
FC0E66 60000124        bra      $FC0F8C

FC0E6A 2EBC00001685    move.l   #$1685,(A7)      Buffer+11, bytes per sectgor
FC0E70 610006BE        bsr      $FC1530          u2i, 8086 to 68000 format
FC0E74 3E00            move.w   D0,D7            Save bytes per sector
FC0E76 6F0E            ble      $FC0E86          < = 0, error
FC0E78 1C3900001687    move.b   $1687,D6         Buffer+13, sectors per cluster
FC0E7E 4886            ext.w    D6
FC0E80 CC7C00FF        and.w    #$FF,D6
FC0E84 6E06            bgt      $FC0E8C          > 0, OK
FC0E86 4280            clr.l    D0               0 as result
FC0E88 60000102        bra      $FC0F8C          Error

FC0E8C 3887            move.w   D7,(A4)          recsize in bpb
FC0E8E 39460002        move.w   D6,2(A4)         clsiz in bpb
FC0E92 2EBC00001690    move.l   #$1690,(A7)      Buffer+22, sectors per FAT
FC0E98 61000696        bsr      $FC1530          u2i, 8086 to 68000 format
FC0E9C 39400008        move.w   D0,8(A4)         fsiz in bpb
FC0EA0 302C0008        move.w   8(A4),D0         fsiz
FC0EA4 5240            addq.w   #1,D0            plus 1
```

```
FC0EA6 3940000A          move.w  D0,10(A4)       as fatrec in bpb
FC0EAA 3014              move.w  (A4),D0         recsize
FC0EAC C1EC0002          muls.w  2(A4),D0        times clsiz
FC0EB0 39400004          move.w  D0,4(A4)        as clsizb in bpb
FC0EB4 2EBC0000168B      move.l  #$168B,(A7)     Buffer+17, number of director entries
FC0EBA 61000674          bsr     $FC1530         u2i, 8086 to 68000 format
FC0EBE EB40              asl.w   #5,D0           times 32
FC0EC0 48C0              ext.l   D0
FC0EC2 81D4              divs.w  (A4),D0         by recsiz
FC0EC4 39400006          move.w  D0,6(A4)        as rdlen in bpb
FC0EC8 302C000A          move.w  10(A4),D0       fatrec
FC0ECC D06C0006          add.w   6(A4),D0        plus rdlen
FC0ED0 D06C0008          add.w   8(A4),D0        plus fsiz
FC0ED4 3940000C          move.w  D0,12(A4)       as datrec in bpb
FC0ED8 2EBC0000168D      move.l  #$168D,(A7)     Buffer+19, number of sectors
FC0EDE 61000650          bsr     $FC1530         u2i, 8086 format to 68000 format
FC0EE2 906C000C          sub.w   12(A4),D0       minus datrec
FC0EE6 48C0              ext.l   D0
FC0EE8 81EC0002          divs.w  2(A4),D0        by clsiz
FC0EEC 3940000E          move.w  D0,14(A4)       as numcl in bpb
FC0EF0 2EBC00001694      move.l  #$1694,(A7)     Buffer+26, number of sides
FC0EF6 61000638          bsr     $FC1530         u2i, 8086 to 68000 format
FC0EFA 3B400014          move.w  D0,20(A5)       as dnsides in bpb
FC0EFE 2EBC00001692      move.l  #$1692,(A7)     Buffer+24, sectors per track
FC0F04 6100062A          bsr     $FC1530         u2i, 8086 to 68000 format
FC0F08 3B400018          move.w  D0,24(A5)       as dspt in bpb
FC0F0C 302D0014          move.w  20(A5),D0       dnsides
FC0F10 C1ED0018          muls.w  24(A5),D0       times dspt
FC0F14 3B400016          move.w  D0,22(A5)       as dspc in bpb
FC0F18 2EBC00001696      move.l  #$1696,(A7)     Buffer+28, number of hidden sectors
FC0F1E 61000610          bsr     $FC1530         u2i, 8086 in 68000 format
FC0F22 3B40001A          move.w  D0,26(A5)       as dhidden in bpb
```

```
FC0F26 2EBC0000168D     move.l   #$168D,(A7)     Buffer+19, number of sectors on disk
FC0F2C 61000602         bsr      $FC1530         u2i, 8086 to 68000 format
FC0F30 48C0             ext.l    D0
FC0F32 81ED0016         divs.w   22(A5),D0       by dspc
FC0F36 3B400012         move.w   D0,18(A5)       as dntracks in bpb
FC0F3A 4247             clr.w    D7              Counter to zero
FC0F3C 6016             bra      $FC0F54         Jump to loop end
FC0F3E 204D             move.l   A5,A0           Buffer pointer
FC0F40 3247             move.w   D7,A1           Counter
FC0F42 D1C9             add.l    A1,A0           plus buffer address
FC0F44 3247             move.w   D7,A1           Counter
FC0F46 D3FC0000167A     add.l    #$167A,A1       Address of disk buffer
FC0F4C 11690008001C     move.b   8(A1),28(A0)    Copy byte of serial number
FC0F52 5247             addq.w   #1,D7           Increment counter
FC0F54 BE7C0003         cmp.w    #3,D7           already 3 ?
FC0F58 6DE4             blt      $FC0F3E         No
FC0F5A 207C000009B4     move.l   #$9B4,A0        cdev
FC0F60 326E0008         move.w   8(A6),A1        Drive
FC0F64 D1C9             add.l    A1,A0
FC0F66 227C000009B2     move.l   #$9B2,A1        wpstatus
FC0F6C 346E0008         move.w   8(A6),A2        Drive
FC0F70 D3CA             add.l    A2,A1
FC0F72 1091             move.b   (A1),(A0)
FC0F74 6704             beq      $FC0F7A
FC0F76 7001             moveq.l  #1,D0           Diskette status uncertain
FC0F78 6002             bra      $FC0F7C
FC0F7A 4240             clr.w    D0              Status certain
FC0F7C 227C00004DB8     move.l   #$4DB8,A1
FC0F82 346E0008         move.w   8(A6),A2        Drive
FC0F86 D3CA             add.l    A2,A1
FC0F88 1280             move.b   D0,(A1)         Save status
FC0F8A 200D             move.l   A5,D0           Address of bpb as result
```

```
FC0F8C 4A9F              tst.l    (A7)+
FC0F8E 4CDF30C0          movem.l  (A7)+,D6-D7/A4-A5    Restore registers
FC0F92 4E5E              unlk     A6
FC0F94 4E75              rts

*************************************************      mediach, disk changed?
FC0F96 4E560000          link     A6,#0
FC0F9A 48E70304          movem.l  D6-D7/A5,-(A7)       Save registers
FC0F9E 0C6E00020008      cmp.w    #2,8(A6)             Drive number < 2 ?
FC0FA4 6D04              blt      $FC0FAA              Yes
FC0FA6 70F1              moveq.l  #-15,D0              'unknown device'
FC0FA8 604C              bra      $FC0FF6              Error exit
FC0FAA 3E2E0008          move.w   8(A6),D7             Drive number
FC0FAE 3A47              move.w   D7,A5
FC0FB0 DBFC00004DB8      add.l    #$4DB8,A5            plus address of bpb
FC0FB6 0C150002          cmp.b    #2,(A5)
FC0FBA 6604              bne      $FC0FC0
FC0FBC 7002              moveq.l  #2,D0                media changed, disk was changed
FC0FBE 6036              bra      $FC0FF6              Error exit
FC0FC0 207C000009B4      move.l   #$9B4,A0             wplatch
FC0FC6 4A307000          tst.b    0(A0,D7.w)           Test for drive
FC0FCA 6704              beq      $FC0FD0              OK ?
FC0FCC 1ABC0001          move.b   #1,(A5)              Status uncertain
FC0FD0 2039000004BA      move.l   $4BA,D0              _hz_200
FC0FD6 3247              move.w   D7,A1
FC0FD8 D3C9              add.l    A1,A1
FC0FDA D3C9              add.l    A1,A1
FC0FDC D3FC000009B6      add.l    #$9B6,A1
FC0FE2 2211              move.l   (A1),D1
FC0FE4 9081              sub.l    D1,D0
FC0FE6 B0B9000029B4      cmp.l    $29B4,D0             maxacctim
FC0FEC 6C04              bge      $FC0FF2
```

```
FC0FEE 4240            clr.w    D0                  ok, disk wasn't changed
FC0FF0 6004            bra      $FC0FF6
FC0FF2 1015            move.b   (A5),D0             Get result
FC0FF4 4880            ext.w    D0
FC0FF6 4A9F            tst.l    (A7)+
FC0FF8 4CDF2080        movem.l  (A7)+,D7/A5         Restore registers
FC0FFC 4E5E            unlk     A6
FC0FFE 4E75            rts

*************************************************** Test for disk change
FC1000 4E560000        link     A6,#0
FC1004 48E70F04        movem.l  D4-D7/A5,-(A7)      Save registers
FC1008 3C2E0008        move.w   8(A6),D6            Drive number
FC100C 3006            move.w   D6,D0
FC100E EB40            asl.w    #5,D0               times 32
FC1010 48C0            ext.l    D0
FC1012 2A40            move.l   D0,A5
FC1014 DBFC00004DCE    add.l    #$4DCE,A5           plus address bpb
FC101A 3E86            move.w   D6,(A7)
FC101C 6100FF78        bsr      $FC0F96             test media change
FC1020 3E00            move.w   D0,D7
FC1022 BE7C0002        cmp.w    #2,D7               Changed ?
FC1026 660A            bne      $FC1032             No
FC1028 3007            move.w   D7,D0
FC102A 6000009C        bra      $FC10C8
FC102E 60000096        bra      $FC10C6

FC1032 BE7C0001        cmp.w    #1,D7               Diskette changed?
FC1036 6600008E        bne      $FC10C6             No
FC103A 3EBC0001        move.w   #1,(A7)             Read sector (boot sector)
FC103E 4267            clr.w    -(A7)               Side 0
FC1040 4267            clr.w    -(A7)               Track 0
```

```
FC1042 3F3C0001        move.w   #1,-(A7)          Sector 1
FC1046 3F06            move.w   D6,-(A7)          Drive number
FC1048 42A7            clr.l    -(A7)             Filler
FC104A 2F3C0000167A    move.l   #$167A,-(A7)      Address of disk buffer
FC1050 4EB900FC159E    jsr      $FC159E           floprd
FC1056 DFFC00000010    add.l    #$10,A7           Correct stack pointer
FC105C 2A00            move.l   D0,D5             Save error number
FC105E 4A85            tst.l    D5                OK ?
FC1060 6C10            bge      $FC1072           Yes
FC1062 3E86            move.w   D6,(A7)
FC1064 2005            move.l   D5,D0             Error number
FC1066 3F00            move.w   D0,-(A7)
FC1068 4EB900FC073E    jsr      $FC073E           Pass to critical error handler
FC106E 548F            addq.l   #2,A7             Correct stack pointer
FC1070 2A00            move.l   D0,D5             Error number
FC1072 BABC00010000    cmp.l    #$10000,D5        Retry ?
FC1078 67C0            beq      $FC103A           Yes, try again
FC107A 4A85            tst.l    D5                Error code
FC107C 6C04            bge      $FC1082           OK ?
FC107E 2005            move.l   D5,D0             Else error number
FC1080 6046            bra      $FC10C8           Error exit
FC1082 4247            clr.w    D7                clear media change status
FC1084 601C            bra      $FC10A2

FC1086 207C0000167A    move.l   #$167A,A0         Address of disk buffer
FC108C 10307008        move.b   8(A0,D7.w),D0     Serial number
FC1090 4880            ext.w    D0
FC1092 1235701C        move.b   28(A5,D7.w),D1    compare with old value
FC1096 4881            ext.w    D1
FC1098 B041            cmp.w    D1,D0             Match ?
FC109A 6704            beq      $FC10A0           Yes
FC109C 7002            moveq.l  #2,D0             Media changed
```

```
FC109E 6028            bra     $FC10C8          Error exit

FC10A0 5247            addq.w  #1,D7            next byte of serial number
FC10A2 BE7C0003        cmp.w   #3,D7            All three bytes tested?
FC10A6 6DDE            blt     $FC1086          No
FC10A8 3046            move.w  D6,A0            Drive number
FC10AA D1FC000009B4    add.l   #$9B4,A0         wplatch
FC10B0 3246            move.w  D6,A1            Drive number
FC10B2 D3FC000009B2    add.l   #$9B2,A1         wpstatus
FC10B8 1091            move.b  (A1),(A0)        accept
FC10BA 660A            bne     $FC10C6
FC10BC 3046            move.w  D6,A0
FC10BE D1FC00004DB8    add.l   #$4DB8,A0
FC10C4 4210            clr.b   (A0)
FC10C6 4240            clr.w   D0               OK
FC10C8 4A9F            tst.l   (A7)+
FC10CA 4CDF20E0        movem.l (A7)+,D5-D7/A5   Restore registers
FC10CE 4E5E            unlk    A6
FC10D0 4E75            rts

*************************************************** rwabs, read/write sector(s)
FC10D2 4E560000        link    A6,#0
FC10D6 48E70700        movem.l D5-D7,-(A7)      Save registers
FC10DA 3E2E0012        move.w  18(A6),D7        Drive number
FC10DE 3007            move.w  D7,D0
FC10E0 B07C0002        cmp.w   #2,D0            Less than 2 ?
FC10E4 6D06            blt     $FC10EC          yes
FC10E6 70F1            moveq.l #-15,D0          'unknown device'
FC10E8 60000068        bra     $FC1152          Error exit

FC10EC 4A79000004A6    tst.w   $4A6             _nflops, floppies connected?
FC10F2 6604            bne     $FC10F8          Yes
```

```
FC10F4 70FE              moveq.l #-2,D0          'Drive not ready'
FC10F6 605A              bra     $FC1152         Error exit

FC10F8 4AAE000A          tst.l   10(A6)          buffer
FC10FC 6616              bne     $FC1114         Address specified?
FC10FE 302E000E          move.w  14(A6),D0       count, number of sectors
FC1102 227C00004DB8      move.l  #$4DB8,A1       Base address
FC1108 346E0012          move.w  18(A6),A2       Drive number
FC110C D3CA              add.l   A2,A1           add
FC110E 1280              move.b  D0,(A1)         Sector counter
FC1110 4280              clr.l   D0              OK
FC1112 603E              bra     $FC1152         Done

FC1114 0C6E00020008      cmp.w   #2,8(A6)        rwflag, ignore media change ?
FC111A 6C1C              bge     $FC1138         Yes
FC111C 3E87              move.w  D7,(A7)         Drive number
FC111E 6100FEE0          bsr     $FC1000         was disk changed?
FC1122 48C0              ext.l   D0
FC1124 2C00              move.l  D0,D6           Save error code
FC1126 4A86              tst.l   D6
FC1128 670E              beq     $FC1138         Not changed, OK
FC112A BCBC00000002      cmp.l   #2,D6           Definitely changed?
FC1130 6602              bne     $FC1134         Yes
FC1132 7CF2              moveq.l #-14,D6         'Diskette was changed'
FC1134 2006              move.l  D6,D0
FC1136 601A              bra     $FC1152         Error exit

FC1138 3EAE000E          move.w  14(A6),(A7)     count, number of sectors
FC113C 3F07              move.w  D7,-(A7)        Drive number
FC113E 3F2E0010          move.w  16(A6),-(A7)    recno, first sector number
FC1142 2F2E000A          move.l  10(A6),-(A7)    buffer
FC1146 3F2E0008          move.w  8(A6),-(A7)     rwflag, read/write
```

```
FC114A 6110               bsr      $FC115C          floprw
FC114C DFFC0000000A       add.l    #$A,A7           Correct stack pointer
FC1152 4A9F               tst.l    (A7)+
FC1154 4CDF00C0           movem.l  (A7)+,D6-D7      Restore registers
FC1158 4E5E               unlk     A6
FC115A 4E75               rts

***********************************************   floprw, read/write sector(s)
FC115C 4E56FFFA           link     A6,#-6
FC1160 48E73F04           movem.l  D2-D7/A5,-(A7)   Restore registers
FC1164 302E0010           move.w   16(A6),D0        Drive number
FC1168 EB40               asl.w    #5,D0            times 32
FC116A 48C0               ext.l    D0
FC116C 2A40               move.l   D0,A5
FC116E DBFC00004DCE       add.l    #$4DCE,A5        plus base address bpb
FC1174 082E0000000D       btst     #0,13(A6)        Buffer address odd?
FC117A 6604               bne      $FC1180          Yes
FC117C 4240               clr.w    D0               Clear odd flag
FC117E 6002               bra      $FC1182
FC1180 7001               moveq.l  #1,D0            Set odd flag
FC1182 3D40FFFE           move.w   D0,-2(A6)        And save
FC1186 4A6D0016           tst.w    22(A5)           dspc set ?
FC118A 660A               bne      $FC1196          Yes
FC118C 7009               moveq.l  #9,D0            Else use 9
FC118E 3B400016           move.w   D0,22(A5)        as dspt
FC1192 3B400018           move.w   D0,24(A5)        and dspc
FC1196 60000180           bra      $FC1318          to loop end

FC119A 4A6EFFFE           tst.w    -2(A6)           Odd flag set?
FC119E 6708               beq      $FC11A8          No
FC11A0 203C0000167A       move.l   #$167A,D0        Address of disk buffer
FC11A6 6004               bra      $FC11AC
```

```
FC11A8 202E000A      move.l  10(A6),D0     Get buffer address
FC11AC 2D40FFFA      move.l  D0,-6(A6)     and save
FC11B0 3C2E000E      move.w  14(A6),D6     recno, logical sector number
FC11B4 48C6          ext.l   D6
FC11B6 8DED0016      divs.w  22(A5),D6     divided by dspc yields track number
FC11BA 382E000E      move.w  14(A6),D4     recno, logical sector number
FC11BE 48C4          ext.l   D4
FC11C0 89ED0016      divs.w  22(A5),D4     divided by dspc, sectors per track
FC11C4 4844          swap    D4            Remainder of division as sector number
FC11C6 B86D0018      cmp.w   24(A5),D4     Compare with dspt
FC11CA 6C04          bge     $FC11D0       Greater than or equal?
FC11CC 4245          clr.w   D5            Side 0
FC11CE 6006          bra     $FC11D6
FC11D0 7A01          moveq.l #1,D5         Side 1
FC11D2 986D0018      sub.w   24(A5),D4     Subtract dspt
FC11D6 4A6EFFFE      tst.w   -2(A6)        Odd-flag set?
FC11DA 6704          beq     $FC11E0       No
FC11DC 7601          moveq.l #1,D3         Set counter to one
FC11DE 6018          bra     $FC11F8
FC11E0 302D0018      move.w  24(A5),D0     dspt
FC11E4 9044          sub.w   D4,D0         minus sector number
FC11E6 B06E0012      cmp.w   18(A6),D0     Compare with number of sectors
FC11EA 6C08          bge     $FC11F4       Greater or equal?
FC11EC 362D0018      move.w  24(A5),D3     dspt
FC11F0 9644          sub.w   D4,D3         minus sector number equals counter
FC11F2 6004          bra     $FC11F8
FC11F4 362E0012      move.w  18(A6),D3     Number of sectors as counter
FC11F8 5244          addq.w  #1,D4         Increment sector number (first sector # = 1)
FC11FA 082E00000009  btst    #0,9(A6)      Test rwflag
FC1200 67000080      beq     $FC1282       Read ?
FC1204 202EFFFA      move.l  -6(A6),D0     Buffer pointer
FC1208 B0AE000A      cmp.l   10(A6),D0     Equals specified buffer address?
```

```
FC120C 6710           beq      $FC121E          Yes
FC120E 2EAEFFFA       move.l   -6(A6),(A7)      Source address
FC1212 2F2E000A       move.l   10(A6),-(A7)     Destination address
FC1216 4EB900FC0AD6   jsr      $FC0AD6          Fastcopy, copy sector
FC121C 588F           addq.l   #4,A7            Correct stack pointer
FC121E 3E83           move.w   D3,(A7)          Number of sectors
FC1220 3F05           move.w   D5,-(A7)         Side
FC1222 3F06           move.w   D6,-(A7)         Track
FC1224 3F04           move.w   D4,-(A7)         Sector
FC1226 3F2E0010       move.w   16(A6),-(A7)     Drive
FC122A 42A7           clr.l    -(A7)            Filler
FC122C 2F2EFFFA       move.l   -6(A6),-(A7)     Buffer
FC1230 4EB900FC167C   jsr      $FC167C          flopwr, write sector(s)
FC1236 DFFC00000010   add.l    #$10,A7          Correct stack pointer
FC123C 2E00           move.l   D0,D7            Error code
FC123E 4A87           tst.l    D7               OK ?
FC1240 663E           bne      $FC1280          No
FC1242 4A7900000444   tst.w    $444             _fverify, verify ?
FC1248 6736           beq      $FC1280          No
FC124A 3E83           move.w   D3,(A7)          Number of sectors
FC124C 3F05           move.w   D5,-(A7)         Side
FC124E 3F06           move.w   D6,-(A7)         Track
FC1250 3F04           move.w   D4,-(A7)         Sector
FC1252 3F2E0010       move.w   16(A6),-(A7)     Drive
FC1256 42A7           clr.l    -(A7)            Filler
FC1258 2F3C0000167A   move.l   #$167A,-(A7)     Address of disk buffer
FC125E 4EB900FC18CE   jsr      $FC18CE          flopver, verify sectors
FC1264 DFFC00000010   add.l    #$10,A7          Correct stack pointer
FC126A 2E00           move.l   D0,D7            Error code
FC126C 4A87           tst.l    D7               OK ?
```

```
FC126E 6610            bne      $FC1280          No
FC1270 2EBC0000167A    move.l   #$167A,(A7)      Address of the disk buffer
FC1276 610002B8        bsr      $FC1530          u2i, convert 8086 integer to 68000 format
FC127A 4A40            tst.w    D0               Bad sector list
FC127C 6702            beq      $FC1280          No errors during verify?
FC127E 7EF0            moveq.l  #-16,D7          'Bad sectors'
FC1280 603A            bra      $FC12BC
FC1282 3E83            move.w   D3,(A7)          Number of sectors
FC1284 3F05            move.w   D5,-(A7)         Side
FC1286 3F06            move.w   D6,-(A7)         Track
FC1288 3F04            move.w   D4,-(A7)         Sector
FC128A 3F2E0010        move.w   16(A6),-(A7)     Drive
FC128E 42A7            clr.l    -(A7)            Filler
FC1290 2F2EFFFA        move.l   -6(A6),-(A7)     Buffer
FC1294 4EB900FC159E    jsr      $FC159E          floprd, read sector(s)
FC129A DFFC00000010    add.l    #$10,A7          Correct stack pointer
FC12A0 2E00            move.l   D0,D7            Error code
FC12A2 202EFFFA        move.l   -6(A6),D0        Buffer used
FC12A6 B0AE000A        cmp.l    10(A6),D0        Equals desired buffer?
FC12AA 6710            beq      $FC12BC          Yes
FC12AC 2EAE000A        move.l   10(A6),(A7)      Source address
FC12B0 2F2EFFFA        move.l   -6(A6),-(A7)     Destination address
FC12B4 4EB900FC0AD6    jsr      $FC0AD6          Fastcopy, copy sector
FC12BA 588F            addq.l   #4,A7            Correct stack pointer
FC12BC 4A87            tst.l    D7               No error?
FC12BE 6C32            bge      $FC12F2          OK
FC12C0 3EAE0010        move.w   16(A6),(A7)      Drive number
FC12C4 2007            move.l   D7,D0            Error code
FC12C6 3F00            move.w   D0,-(A7)
FC12C8 4EB900FC073E    jsr      $FC073E          critical error handler
FC12CE 548F            addq.l   #2,A7            Correct stack pointer
FC12D0 2E00            move.l   D0,D7            Save error code
```

```
FC12D2 0C6E00020008        cmp.w    #2,8(A6)          rwflag, ignore media change ?
FC12D8 6C18                bge      $FC12F2           Yes
FC12DA BEBC00010000        cmp.l    #$10000,D7        Retry ?
FC12E0 6610                bne      $FC12F2           No
FC12E2 3EAE0010            move.w   16(A6),(A7)       Drive number
FC12E6 6100FD18            bsr      $FC1000           Diskette change ?
FC12EA B07C0002            cmp.w    #2,D0             Definitely changed?
FC12EE 6602                bne      $FC12F2           No
FC12F0 7EF2                moveq.l  #-14,D7           'media changed'
FC12F2 BEBC00010000        cmp.l    #$10000,D7        Retry ?
FC12F8 6700FF00            beq      $FC11FA           Yes, try again
FC12FC 4A87                tst.l    D7                Error code
FC12FE 6C04                bge      $FC1304           OK ?
FC1300 2007                move.l   D7,D0             Error code
FC1302 601E                bra      $FC1322           To error exit
FC1304 3003                move.w   D3,D0             Sector counter
FC1306 48C0                ext.l    D0
FC1308 7209                moveq.l  #9,D1
FC130A E3A0                asl.l    D1,D0             times 512
FC130C D1AE000A            add.l    D0,10(A6)         Increment buffer address
FC1310 D76E000E            add.w    D3,14(A6)         Logical sector number plus sector counter
FC1314 976E0012            sub.w    D3,18(A6)         Decrement number of sectors to process
FC1318 4A6E0012            tst.w    18(A6)            Still sectors to process?
FC131C 6600FE7C            bne      $FC119A           Yes
FC1320 4280                clr.l    D0                OK
FC1322 4A9F                tst.l    (A7)+
FC1324 4CDF20F8            movem.l  (A7)+,D3-D7/A5    Restore registers
FC1328 4E5E                unlk     A6
FC132A 4E75                rts

*****************************************************  random, generate random numbers
FC132C 4E56FFFC            link     A6,#-4
```

```
FC1330 4AB9000029B8        tst.l    $29B8                Last random number
FC1336 6616                bne      $FC134E              Not zero?
FC1338 2039000004BA        move.l   $4BA,D0              _hz_200
FC133E 7210                moveq.l  #16,D1
FC1340 E3A0                asl.l    D1,D0                << 16
FC1342 80B9000004BA        or.l     $4BA,D0              _hz_200
FC1348 23C0000029B8        move.l   D0,$29B8             Use as start value
FC134E 2F3CBB40E62D        move.l   #3141592621,-(A7)
FC1354 2F39000029B8        move.l   $29B8,-(A7)          Last random value
FC135A 4EB900FC4BE4        jsr      $FC4BE4              Long multiplication
FC1360 508F                addq.l   #8,A7                Correct stack pointer
FC1362 5280                addq.l   #1,D0                plus
FC1364 23C0000029B8        move.l   D0,$29B8             as new start value
FC136A 2039000029B8        move.l   $29B8,D0             Result
FC1370 E080                asr.l    #8,D0                >> 8
FC1372 C0BC00FFFFFF        and.l    #$FFFFFF,D0          Clear bits 24-31
FC1378 4E5E                unlk     A6
FC137A 4E75                rts

*******************************************************  hdv_boot, load boot sector
FC137C 4E560000            link     A6,#0
FC1380 48E70300            movem.l  D6-D7,-(A7)          Save registers
FC1384 4EB900FC0AF8        jsr      $FC0AF8              hdv_init, initialize drive
FC138A 4A79000004A6        tst.w    $4A6                 _nflops
FC1390 6704                beq      $FC1396              No drive connected?
FC1392 7001                moveq.l  #1,D0                'couldn't load'
FC1394 6002                bra      $FC1398
FC1396 7002                moveq.l  #2,D0                'no drive'
FC1398 3E00                move.w   D0,D7                Save error
FC139A 4A79000004A6        tst.w    $4A6                 _nflops
FC13A0 6744                beq      $FC13E6              No drive?
FC13A2 0C7900020000446     cmp.w    #2,$446              _bootdev
```

```
FC13AA 6C3A              bge      $FC13E6         No diskette?
FC13AC 3EBC0001          move.w   #1,(A7)         One sector
FC13B0 4267              clr.w    -(A7)           Side 0
FC13B2 4267              clr.w    -(A7)           Track 0
FC13B4 3F3C0001          move.w   #1,-(A7)        Sector 1
FC13B8 3F3900000446      move.w   $446,-(A7)      _bootdev
FC13BE 42A7              clr.l    -(A7)           Filler
FC13C0 2F3C0000167A      move.l   #$167A,-(A7)    Address of disk buffer
FC13C6 4EB900FC159E      jsr      $FC159E         floprd, read sector
FC13CC DFFC00000010      add.l    #$10,A7         Correct stack pointer
FC13D2 4A80              tst.l    D0              Error ?
FC13D4 6604              bne      $FC13DA         Yes
FC13D6 4247              clr.w    D7              Clear error code
FC13D8 600C              bra      $FC13E6
FC13DA 4A39000009B2      tst.b    $9B2            wpstatus
FC13E0 6604              bne      $FC13E6
FC13E2 7003              moveq.l  #3,D0           'unreadable'
FC13E4 6024              bra      $FC140A
FC13E6 4A47              tst.w    D7              Error ?
FC13E8 6704              beq      $FC13EE         No
FC13EA 3007              move.w   D7,D0           Get error code
FC13EC 601C              bra      $FC140A
FC13EE 3EBC0100          move.w   #$100,(A7)      $100 words
FC13F2 2F3C0000167A      move.l   #$167A,-(A7)    Address of disk buffer
FC13F8 61000106          bsr      $FC1500         Calculate checksum
FC13FC 588F              addq.l   #4,A7           Correct stack pointer
FC13FE B07C1234          cmp.w    #$1234,D0       magic for boot sector?
FC1402 6604              bne      $FC1408         No
FC1404 4240              clr.w    D0              OK
FC1406 6002              bra      $FC140A
FC1408 7004              moveq.l  #4,D0           'not valid boot sector'
FC140A 4A9F              tst.l    (A7)+
```

```
FC140C 4CDF0080        movem.l (A7)+,D7        Restore registers
FC1410 4E5E            unlk    A6
FC1412 4E75            rts

*****************************************************  proto_bt, generate boot sector
FC1414 4E56FFFA        link    A6,#-6
FC1418 48E70704        movem.l D5-D7/A5,-(A7)  Restore registers
FC141C 4A6E0012        tst.w   18(A6)          Test execflg
FC1420 6C1E            bge     $FC1440         Preserve executability
FC1422 3EBC0100        move.w  #$100,(A7)      $100 words
FC1426 2F2E0008        move.l  8(A6),-(A7)     Address of the sector buffer
FC142A 610000D4        bsr     $FC1500         Calculate checksum
FC142E 588F            addq.l  #4,A7           Correct stack pointer
FC1430 B07C1234        cmp.w   #$1234,D0       magic for boot sector?
FC1434 6704            beq     $FC143A         Yes
FC1436 4240            clr.w   D0              Not executable
FC1438 6002            bra     $FC143C
FC143A 7001            moveq.l #1,D0           Executable
FC143C 3D400012        move.w  D0,18(A6)       execflg
FC1440 4AAE000C        tst.l   12(A6)          Serial number
FC1444 6D3E            blt     $FC1484         Negative, don't change
FC1446 202E000C        move.l  12(A6),D0       Serial number
FC144A B0BC00FFFFFF    cmp.l   #$FFFFFF,D0     > $FFFFFF ?
FC1450 6F08            ble     $FC145A         No
FC1452 6100FED8        bsr     $FC132C         rand, create random number
FC1456 2D40000C        move.l  D0,12(A6)       as serial number
FC145A 4247            clr.w   D7              Clear counter
FC145C 6020            bra     $FC147E
FC145E 202E000C        move.l  12(A6),D0       Serial number
FC1462 C0BC000000FF    and.l   #$FF,D0         Bits 0-7
FC1468 3247            move.w  D7,A1           Pointer to next byte in buffer
FC146A D3EE0008        add.l   8(A6),A1        plus buffer address
```

```
FC146E 13400008        move.b  D0,8(A1)         Byte of the serial number in buffer
FC1472 202E000C        move.l  12(A6),D0        Serial number
FC1476 E080            asr.l   #8,D0            >> 8
FC1478 2D40000C        move.l  D0,12(A6)
FC147C 5247            addq.w  #1,D7            Increment counter
FC147E BE7C0003        cmp.w   #3,D7            already 3 ?
FC1482 6DDA            blt     $FC145E          No
FC1484 4A6E0010        tst.w   16(A6)           Disk size
FC1488 6D28            blt     $FC14B2          Negative, don't change
FC148A 3C2E0010        move.w  16(A6),D6        Disk size
FC148E CDFC0013        muls.w  #$13,D6          times 19 equals pointer to prototype bpb
FC1492 4247            clr.w   D7               Clear counter
FC1494 6016            bra     $FC14AC
FC1496 3047            move.w  D7,A0            Counter
FC1498 D1EE0008        add.l   8(A6),A0         plus buffer address
FC149C 3246            move.w  D6,A1            Disk size
FC149E D3FC00FD1B60    add.l   #$FD1B60,A1      plus address of the prototype bpb
FC14A4 1151000B        move.b  (A1),11(A0)      Copy bpb
FC14A8 5246            addq.w  #1,D6
FC14AA 5247            addq.w  #1,D7            Increment counter
FC14AC BE7C0013        cmp.w   #$13,D7          already 19 ?
FC14B0 6DE4            blt     $FC1496          No
FC14B2 426EFFFA        clr.w   -6(A6)
FC14B6 2D6E0008FFFC    move.l  8(A6),-4(A6)     Buffer address
FC14BC 600E            bra     $FC14CC
FC14BE 206EFFFC        move.l  -4(A6),A0        Buffer address
FC14C2 3010            move.w  (A0),D0          Get word from buffer
FC14C4 D16EFFFA        add.w   D0,-6(A6)        Add to checksum
FC14C8 54AEFFFC        addq.l  #2,-4(A6)        Next word
FC14CC 202E0008        move.l  8(A6),D0         Buffer address
FC14D0 D0BC000001FE    add.l   #$1FE,D0         plus $1FE
FC14D6 B0AEFFFC        cmp.l   -4(A6),D0        Last word?
```

```
FC14DA 62E2          bhi      $FC14BE         No
FC14DC 303C1234      move.w   #$1234,D0       Checksum for boot sector
FC14E0 906EFFFA      sub.w    -6(A6),D0       subtract from previous value
FC14E4 226EFFFC      move.l   -4(A6),A1
FC14E8 3280          move.w   D0,(A1)         Checksum in buffer
FC14EA 4A6E0012      tst.w    18(A6)          execflg
FC14EE 6606          bne      $FC14F6         Boot sector executable?
FC14F0 206EFFFC      move.l   -4(A6),A0
FC14F4 5250          addq.w   #1,(A0)         Increment checksum, not executable
FC14F6 4A9F          tst.l    (A7)+
FC14F8 4CDF20C0      movem.l  (A7)+,D6-D7/A5  Restore registers
FC14FC 4E5E          unlk     A6
FC14FE 4E75          rts

*********************************************************  Calculate checksum
FC1500 4E560000      link     A6,#0
FC1504 48E70300      movem.l  D6-D7,-(A7)     Restore registers
FC1508 4247          clr.w    D7              Clear sum
FC150A 600C          bra      $FC1518         To loop end
FC150C 206E0008      move.l   8(A6),A0        Address of the buffer
FC1510 3010          move.w   (A0),D0         Get word
FC1512 DE40          add.w    D0,D7           sum
FC1514 54AE0008      addq.l   #2,8(A6)        Increment buffer address
FC1518 302E000C      move.w   12(A6),D0       Number of words
FC151C 536E000C      subq.w   #1,12(A6)       minus 1
FC1520 4A40          tst.w    D0              All words added?
FC1522 66E8          bne      $FC150C         No
FC1524 3007          move.w   D7,D0           Result to D0
FC1526 4A9F          tst.l    (A7)+
FC1528 4CDF0080      movem.l  (A7)+,D7        Restore registers
FC152C 4E5E          unlk     A6
FC152E 4E75          rts
```

```
*****************************************************   u2i, 8086 integer to 68000 format
FC1530 4E56FFFC              link     A6,#-4
FC1534 206E0008              move.l   8(A6),A0          Address of the number
FC1538 10280001              move.b   1(A0),D0          Hi byte
FC153C 4880                  ext.w    D0
FC153E C07C00FF              and.w    #$FF,D0           Isolate bits 0-7
FC1542 E140                  asl.w    #8,D0             Shift to bits 8-15
FC1544 226E0008              move.l   8(A6),A1          Address of the number
FC1548 1211                  move.b   (A1),D1           Gte lo-byte
FC154A 4881                  ext.w    D1
FC154C C27C00FF              and.w    #$FF,D1           Isolate bits 0-7
FC1550 8041                  or.w     D1,D0             Combine with high byte
FC1552 4E5E                  unlk     A6
FC1554 4E75                  rts

*****************************************************   flopini, initialize drive
FC1556 43F900000A06          lea      $A06,A1           Address of dsb0
FC155C 4A6F000C              tst.w    12(A7)            Drive A ?
FC1560 6706                  beq      $FC1568           Yes
FC1562 43F900000A0A          lea      $A0A,A1           Else address of dsb1
FC1568 3379000004400002      move.w   $440,2(A1)        Seek rate in dsb
FC1570 70FF                  moveq.l  #-1,D0            Default error number
FC1572 42690000              clr.w    (A1)              Track number to zero
FC1576 610004BC              bsr      $FC1A34           floplock, set parameters
FC157A 61000698              bsr      $FC1C14           select, select drive and side
FC157E 337CFF000000          move.w   #$FF00,(A1)       Track number negative, invalid
FC1584 6100061A              bsr      $FC1BA0           restore, track zero
FC1588 670C                  beq      $FC1596           OK, flopok
FC158A 7E0A                  moveq.l  #10,D7            Track 10
FC158C 610005A0              bsr      $FC1B2E           hseek, find track
FC1590 6608                  bne      $FC159A           Error, flopfail
FC1592 6100060C              bsr      $FC1BA0           restore
```

```
FC1596 67000542          beq      $FC1ADA              OK, flopok
FC159A 60000530          bra      $FC1ACC              flopfail

*****************************************************  floprd, read sector(s) from disk
FC159E 6100071E          bsr      $FC1CBE              change, test for disk change
FC15A2 70F5              moveq.l  #-11,D0              Read error as error number
FC15A4 6100048E          bsr      $FC1A34              floplock, set parameters
FC15A8 6100066A          bsr      $FC1C14              select, select drive and side
FC15AC 610005CC          bsr      $FC1B7A              go2track, find track
FC15B0 66000090          bne      $FC1642              Try again if error
FC15B4 33FCFFFF000009E0  move.w   #-1,$9E0             General error
FC15BC 3CBC0090          move.w   #$90,(A6)
FC15C0 3CBC0190          move.w   #$190,(A6)           Clear DMA status, select read
FC15C4 3CBC0090          move.w   #$90,(A6)
FC15C8 33ED09CAFFFF8604  move.w   $9CA(A5),$FFFF8604   ccount, sector counter
FC15D0 3CBC0080          move.w   #$80,(A6)            Select 1772
FC15D4 3E3C0090          move.w   #$90,D7              Read multiple sectors
FC15D8 610006B6          bsr      $FC1C90              wdiskctl, pass D7 to 1772
FC15DC 2E3C00040000      move.l   #$40000,D7           Timeout counter
FC15E2 246D09D0          move.l   $9D0(A5),A2          edma, end address for DMA
FC15E6 08390005FFFFFA01  btst     #5,$FFFFFA01         mfp gpip, 1772 done ?
FC15EE 6734              beq      $FC1624              Yes
FC15F0 5387              subq.l   #1,D7                Decrement counter
FC15F2 6724              beq      $FC1618              Timeout ?
FC15F4 1B79FFFF860909DB  move.b   $FFFF8609,$9DB(A5)
FC15FC 1B79FFFF860B09DC  move.b   $FFFF860B,$9DC(A5)   DMA address
FC1604 1B79FFFF860D09DD  move.b   $FFFF860D,$9DD(A5)
FC160C B5ED09DA          cmp.l    $9DA(A5),A2          End address reached?
FC1610 6ED4              bgt      $FC15E6              No
FC1612 610005E6          bsr      $FC1BFA              reset, end transfer
FC1616 600C              bra      $FC1624
FC1618 3B7CFFFE09E0      move.w   #-2,$9E0(A5)         Drive not ready
```

```
FC161E 610005DA        bsr      $FC1BFA           reset, end transfer
FC1622 601E            bra      $FC1642
FC1624 3CBC0090        move.w   #$90,(A6)         Select DMA status register
FC1628 3016            move.w   (A6),D0           Read status
FC162A 08000000        btst     #0,D0             DMA error ?
FC162E 6712            beq      $FC1642           Yes, try again
FC1630 3CBC0080        move.w   #$80,(A6)         Select 1772
FC1634 6100066E        bsr      $FC1CA4           rdiskctl, read status register
FC1638 C03C0018        and.b    #$18,D0           Isolate RNF, CRC and Lost Data
FC163C 6700049C        beq      $FC1ADA           No error, flopok
FC1640 6118            bsr      $FC165A           errbits, determine error number
FC1642 0C6D000109B0    cmp.w    #1,$9B0(A5)       retrycnt to second attempt?
FC1648 6604            bne      $FC164E           No
FC164A 610004FA        bsr      $FC1B46           ressek, home and seek
FC164E 536D09B0        subq.w   #1,$9B0(A5)       Decrement retrycnt
FC1652 6A00FF54        bpl      $FC15A8           Another attempt?
FC1656 60000474        bra      $FC1ACC           No, flopfail

*************************************************  errbits, create floppy error number
FC165A 72F3            moveq.l  #-13,D1           Diskette write-protected
FC165C 08000006        btst     #6,D0             Write protect ?
FC1660 6614            bne      $FC1676           Yes
FC1662 72F8            moveq.l  #-8,D1            Sector not found
FC1664 08000004        btst     #4,D0             Sector not found ?
FC1668 660C            bne      $FC1676           Yes
FC166A 72FC            moveq.l  #-4,D1            CRC Error
FC166C 08000003        btst     #3,D0             CRC Error ?
FC1670 6704            beq      $FC1676           No
FC1672 322D09DE        move.w   $9DE(A5),D1       Default error
FC1676 3B4109E0        move.w   D1,$9E0(A5)
FC167A 4E75            rts
```

```
******************************************************   flopwr, write sector(s) to disk
FC167C 61000640          bsr      $FC1CBE          change, test for disk change
FC1680 70F6              moveq.l  #-10,D0          Write error as default error
FC1682 610003B0          bsr      $FC1A34          floplock, set parameters
FC1686 302D09C6          move.w   $9C6(A5),D0      csect, sector number 1 ?
FC168A 5340              subq.w   #1,D0
FC168C 806D09C4          or.w     $9C4(A5),D0      ctrack, track number 0
FC1690 806D09C8          or.w     $9C8(A5),D0      cside, side 0 ?
FC1694 6606              bne      $FC169C          No, not boot sector
FC1696 7002              moveq.l  #2,D0            media change
FC1698 6100065C          bsr      $FC1CF6          Set to 'unsure'
FC169C 61000576          bsr      $FC1C14          select, select track and side
FC16A0 610004D8          bsr      $FC1B7A          go2track, find track
FC16A4 6600007E          bne      $FC1724          Error, try again
FC16A8 3B7CFFFF09E0      move.w   #-1,$9E0(A5)     currerr to default
FC16AE 3CBC0190          move.w   #$190,(A6)
FC16B2 3CBC0090          move.w   #$90,(A6)        Clear DMA status, to write
FC16B6 3CBC0190          move.w   #$190,(A6)
FC16BA 3E3C0001          move.w   #1,D7            Sector count register
FC16BE 610005D0          bsr      $FC1C90          wdiskctl, D7 to 1772
FC16C2 3CBC0180          move.w   #$180,(A6)       Select 1772
FC16C6 3E3C00A0          move.w   #$A0,D7          Write sector
FC16CA 610005C4          bsr      $FC1C90          wdiskctl, D7 to 1772
FC16CE 2E3C00040000      move.l   #$40000,D7       Timeout counter
FC16D4 08390005FFFFFA01  btst     #5,$FFFFFA01     mfp gpip, 1772 done ?
FC16DC 670A              beq      $FC16E8          Yes
FC16DE 5387              subq.l   #1,D7            Decrement timeout counter
FC16E0 66F2              bne      $FC16D4          Timeout?
FC16E2 61000516          bsr      $FC1BFA          reset, terminate transfer
FC16E6 6034              bra      $FC171C          Next try
FC16E8 3CBC0180          move.w   #$180,(A6)       Select 1772
```

```
FC16EC 610005B6           bsr      $FC1CA4          rdiskctl, read status register
FC16F0 6100FF68           bsr      $FC165A          errbits, calculate error number
FC16F4 08000006           btst     #6,D0            write protect ?
FC16F8 660003D2           bne      $FC1ACC          flopfail, no further attempt
FC16FC C03C005C           and.b    #$5C,D0          write protect, RNF, CRC and Lost Data
FC1700 661A               bne      $FC171C          Error, try again
FC1702 526D09C6           addq.w   #1,$9C6(A5)      csect, increment sector number
FC1706 06AD0000020009CC   add.l    #512,$9CC(A5)    cdma, DMA address to next sector
FC170E 536D09CA           subq.w   #1,$9CA(A5)      ccount, decrement number of sectors
FC1712 670003C6           beq      $FC1ADA          All sectors, done, flopok
FC1716 61000524           bsr      $FC1C3C          select1, sector number and DMA pointer
FC171A 608C               bra      $FC16A8          Write next sector without seek
FC171C 0C6D000109B0       cmp.w    #1,$9B0(A5)      retrycnt, second try?
FC1722 6604               bne      $FC1728          No
FC1724 61000420           bsr      $FC1B46          reseek, home and seek
FC1728 536D09B0           subq.w   #1,$9B0(A5)      retrycnt, decrement try counter
FC172C 6A00FF6E           bpl      $FC169C          Another try?
FC1730 6000039A           bra      $FC1ACC          No, flopfail

*************************************************** flopfmt, format track
FC1734 0CAF876543210016   cmp.l    #$87654321,22(A7) Magic number ?
FC173C 6600038E           bne      $FC1ACC          No, flopfail
FC1740 6100057C           bsr      $FC1CBE          change, test for disk change
FC1744 70FF               moveq.l  #-1,D0           Default Error Nummer
FC1746 610002EC           bsr      $FC1A34          floplock, set parameters
FC174A 610004C8           bsr      $FC1C14          select, select drive and side
FC174E 3B6F000E09D4       move.w   14(A7),$9D4(A5)  spt, sectors per track
FC1754 3B6F001409D6       move.w   20(A7),$9D6(A5)  interlv, interleave factor
FC175A 3B6F001A09D8       move.w   26(A7),$9D8(A5)  virgin, sector data for formatting
FC1760 7002               moveq.l  #2,D0            'changed'
FC1762 61000592           bsr      $FC1CF6          Diskette changed
FC1766 610003C0           bsr      $FC1B28          hseek, search for track
```

```
FC176A 66000360          bne      $FC1ACC             Not found, flopfail
FC176E 336D09C40000      move.w   $9C4(A5),(A1)       ctrack, write current track in DSB
FC1774 3B7CFFFF09E0      move.w   #-1,$9E0(A5)        General error
FC177A 6128              bsr      $FC17A4             Format track
FC177C 6600034E          bne      $FC1ACC             flopfail, error
FC1780 3B6D09D409CA      move.w   $9D4(A5),$9CA(A5)   spt sectors per track as ccount counter
FC1786 3B7C000109C6      move.w   #1,$9C6(A5)         csect, start with sector 1
FC178C 6100015C          bsr      $FC18EA             verify, verify sector
FC1790 246D09CC          move.l   $9CC(A5),A2         cdma, list with bad sectors
FC1794 4A52              tst.w    (A2)                Bad sector?
FC1796 67000342          beq      $FC1ADA             No, flopok
FC179A 3B7CFFF009E0      move.w   #-16,$9E0(A5)       Bad sectors
FC17A0 6000032A          bra      $FC1ACC             flopfail, error

*****************************************************  fmtrack, format track
FC17A4 3B7CFFF609DE      move.w   #-10,$9DE(A5)       Write error
FC17AA 363C0001          move.w   #1,D3               Start with sector 1
FC17AE 246D09CC          move.l   $9CC(A5),A2         cdma, buffer for track data
FC17B2 323C003B          move.w   #$3B,D1             60 times
FC17B6 103C004E          move.b   #$4E,D0             $4E, track header
FC17BA 6100010A          bsr      $FC18C6             wmult, write in buffer
FC17BE 3803              move.w   D3,D4               Save sector number
FC17C0 323C000B          move.w   #$B,D1              12 times
FC17C4 4200              clr.b    D0                  0
FC17C6 610000FE          bsr      $FC18C6             wmult, write in buffer
FC17CA 323C0002          move.w   #2,D1               3 times
FC17CE 103C00F5          move.b   #$F5,D0             $F5
FC17D2 610000F2          bsr      $FC18C6             wmult, write in buffer
FC17D6 14FC00FE          move.b   #$FE,(A2)+          $FE, address mark
FC17DA 14F9000009C5      move.b   $9C5,(A2)+          Track
FC17E0 14F9000009C9      move.b   $9C9,(A2)+          Side
FC17E6 14C4              move.b   D4,(A2)+            Sector
```

```
FC17E8 14FC0002           move.b  #2,(A2)+              Sector size 512 bytes
FC17EC 14FC00F7           move.b  #$F7,(A2)+            Write checksum
FC17F0 323C0015           move.w  #$15,D1               22 times
FC17F4 103C004E           move.b  #$4E,D0               $4E
FC17F8 610000CC           bsr     $FC18C6               wmult, write in buffer
FC17FC 323C000B           move.w  #$B,D1                12 times
FC1800 4200               clr.b   D0                    0
FC1802 610000C2           bsr     $FC18C6               wmult, write in buffer
FC1806 323C0002           move.w  #2,D1                 3 times
FC180A 103C00F5           move.b  #$F5,D0               $F5
FC180E 610000B6           bsr     $FC18C6               wmult, write in buffer
FC1812 14FC00FB           move.b  #$FB,(A2)+            $FB, data block mark
FC1816 323C00FF           move.w  #$FF,D1               256 times
FC181A 14ED09D8           move.b  $9D8(A5),(A2)+        virgin, initial data in buffer
FC181E 14ED09D9           move.b  $9D9(A5),(A2)+
FC1822 51C9FFF6           dbra    D1,$FC181A            Next word
FC1826 14FC00F7           move.b  #$F7,(A2)+            Write checksum
FC182A 323C0027           move.w  #$27,D1               40 times
FC182E 103C004E           move.b  #$4E,D0               $4E
FC1832 61000092           bsr     $FC18C6               wmult, write in buffer
FC1836 D86D09D6           add.w   $9D6(A5),D4           Add interlv, next sector
FC183A B86D09D4           cmp.w   $9D4(A5),D4           spt, largest sector number
FC183E 6F80               ble     $FC17C0               No, next sector
FC1840 5243               addq.w  #1,D3                 Start sector plus one
FC1842 B66D09D6           cmp.w   $9D6(A5),D3           interlv
FC1846 6F00FF76           ble     $FC17BE               Next sector
FC184A 323C0578           move.w  #$578,D1              1401 times (until track end)
FC184E 103C004E           move.b  #$4E,D0               $4E
FC1852 6172               bsr     $FC18C6               wmult, write in buffer
FC1854 13ED09CFFFFF860D   move.b  $9CF(A5),$FFFF860D    dmalow
FC185C 13ED09CEFFFF860B   move.b  $9CE(A5),$FFFF860B    dmamid
FC1864 13ED09CDFFFF8609   move.b  $9CD(A5),$FFFF8609    dmahigh
```

```
FC186C 3CBC0190           move.w   #$190,(A6)
FC1870 3CBC0090           move.w   #$90,(A6)            Clear DMA status, write
FC1874 3CBC0190           move.w   #$190,(A6)
FC1878 3E3C001F           move.w   #$1F,D7              Sector counter to 31
FC187C 61000412           bsr      $FC1C90              wdiskctl, send D7 to 1772
FC1880 3CBC0180           move.w   #$180,(A6)           Select 1772
FC1884 3E3C00F0           move.w   #$F0,D7              Format Track command
FC1888 61000406           bsr      $FC1C90              wdiskctl, send D7 to 1772
FC188C 2E3C00040000       move.l   #$40000,D7           Timeout counter
FC1892 08390005FFFFFA01   btst     #5,$FFFFFA01         mfp gpip, 1772 done ?
FC189A 670C               beq      $FC18A8              Yes
FC189C 5387               subq.l   #1,D7                Decrement timeout counter
FC189E 66F2               bne      $FC1892              Run out?
FC18A0 61000358           bsr      $FC1BFA              Reset, terminate
FC18A4 7E01               moveq.l  #1,D7                Clear Z-bit, error
FC18A6 4E75               rts

FC18A8 3CBC0190           move.w   #$190,(A6)           Select DMA status
FC18AC 3016               move.w   (A6),D0              Read status
FC18AE 08000000           btst     #0,D0                DMA error ?
FC18B2 67F0               beq      $FC18A4              Yes, error
FC18B4 3CBC0180           move.w   #$180,(A6)           Select 1772 status register
FC18B8 610003EA           bsr      $FC1CA4              rdiskctl, read register
FC18BC 6100FD9C           bsr      $FC165A              errbits, calculate error number
FC18C0 C03C0044           and.b    #$44,D0              Test write protect and lost data
FC18C4 4E75               rts

FC18C6 14C0               move.b   D0,(A2)+             Write byte in buffer
FC18C8 51C9FFFC           dbra     D1,$FC18C6           Next byte
FC18CC 4E75               rts

*****************************************************   flopver, verify sector(s)
```

```
FC18CE 610003EE           bsr      $FC1CBE              change, test for disk change
FC18D2 70F5               moveq.l  #-11,D0              Read error as default error
FC18D4 6100015E           bsr      $FC1A34              floplock, set parameter
FC18D8 6100033A           bsr      $FC1C14              select
FC18DC 6100029C           bsr      $FC1B7A              go2track, find track
FC18E0 660001EA           bne      $FC1ACC              flopfail, error
FC18E4 6104               bsr      $FC18EA              verify1, verify sectors
FC18E6 600001F2           bra      $FC1ADA              flopok, done

************************************************        verify1
FC18EA 3B7CFFF509DE       move.w   #-11,$9DE(A5)        Read error
FC18F0 246D09CC           move.l   $9CC(A5),A2          cdma, DMA buffer for bad-sector list
FC18F4 06AD0000020009CC   add.l    #512,$9CC(A5)        cmda to next sector
FC18FC 3B7C000209B0       move.w   #2,$9B0(A5)          retrycnt, 2 tries
FC1902 3CBC0084           move.w   #$84,(A6)            Select sector register
FC1906 3E2D09C6           move.w   $9C6(A5),D7          csect, sector number
FC190A 61000384           bsr      $FC1C90              wdiskctl, D7 to 1772
FC190E 13ED09CFFFFF860D   move.b   $9CF(A5),$FFFF860D
FC1916 13ED09CEFFFF860B   move.b   $9CE(A5),$FFFF860B   Set DMA address
FC191E 13ED09CDFFFF8609   move.b   $9CD(A5),$FFFF8609
FC1926 3CBC0090           move.w   #$90,(A6)
FC192A 3CBC0190           move.w   #$190,(A6)           Clar DMA status, read
FC192E 3CBC0090           move.w   #$90,(A6)
FC1932 3E3C0001           move.w   #1,D7                Sector counter to 1
FC1936 61000358           bsr      $FC1C90              wdiskctl, D7 to 1772
FC193A 3CBC0080           move.w   #$80,(A6)            Select 1772 command register
FC193E 3E3C0080           move.w   #$80,D7              Read Sector command
FC1942 6100034C           bsr      $FC1C90              wdiskctl, D7 to 1772
FC1946 2E3C00040000       move.l   #$40000,D7           Timeout counter
FC194C 08390005FFFFFA01   btst     #5,$FFFFFA01         mfp gpip, 1772 done?
FC1954 670A               beq      $FC1960              Yes
FC1956 5387               subq.l   #1,D7                Decrement timeout counter
```

```
FC1958 66F2              bne      $FC194C          Run out?
FC195A 6100029E          bsr      $FC1BFA          Reset 1772, terminate transfer
FC195E 6036              bra      $FC1996          Next try
FC1960 3CBC0090          move.w   #$90,(A6)        Select DMA status register
FC1964 3016              move.w   (A6),D0          Read status
FC1966 08000000          btst     #0,D0            DMA error ?
FC196A 672A              beq      $FC1996          Yes, try again
FC196C 3CBC0080          move.w   #$80,(A6)        Select 1772 status register
FC1970 61000332          bsr      $FC1CA4          rdiskctl, read status
FC1974 6100FCE4          bsr      $FC165A          errbits, calculate error number
FC1978 C03C001C          and.b    #$1C,D0          Test RNF, CRC and Lost Data
FC197C 6618              bne      $FC1996          Error next try
FC197E 526D09C6          addq.w   #1,$9C6(A5)      csect, next sector
FC1982 536D09CA          subq.w   #1,$9CA(A5)      ccount, decrement sector counter
FC1986 6600FF74          bne      $FC18FC          Another sector?
FC198A 04AD0000020009CC  sub.l    #512,$9CC(A5)    cdma, reset DMA pointer
FC1992 4252              clr.w    (A2)             Terminate bad sector list with zero
FC1994 4E75              rts       ¿nl¡¿a3¡
FC1996 0C6D000109B0      cmp.w    #1,$9B0(A5)      retrycnt,2nd try?
FC199C 6604              bne      $FC19A2          No
FC199E 610001A6          bsr      $FC1B46          reseek, home and seek
FC19A2 536D09B0          subq.w   #1,$9B0(A5)      Decrement retrycnt
FC19A6 6A00FF66          bpl      $FC190E          Another try?
FC19AA 34ED09C6          move.w   $9C6(A5),(A2)+   csect, sector number in bad sector list
FC19AE 60CE              bra      $FC197E          Next sector

*****************************************************  flopvbl, Floppy Vertical Blank Handler
FC19B0 9BCD              sub.l    A5,A5            Clear A5
FC19B2 4DF9FFFF8606      lea      $FFFF8606,A6     Address of the floppy register
FC19B8 50ED09BE          st       $9BE(A5)         Set motor on flag
FC19BC 4A6D043E          tst.w    $43E(A5)         flock, floppies active ?
FC19C0 6670              bne      $FC1A32          Yes, do nothing
```

```
FC19C2 203900000466      move.l  $466,D0          _frclock
FC19C8 1200              move.b  D0,D1
FC19CA C23C0007          and.b   #7,D1            Calculate mod 8
FC19CE 6638              bne     $FC1A08          8th interrupt ?
FC19D0 3CBC0080          move.w  #$80,(A6)        Select 1772 status register
FC19D4 E608              lsr.b   #3,D0            Bit 4 as drive number
FC19D6 C07C0001          and.w   #1,D0
FC19DA 41ED09B2          lea     $9B2(A5),A0      wpstatus
FC19DE D0C0              add.w   D0,A0
FC19E0 B079000004A6      cmp.w   $4A6,D0          _nflops
FC19E6 6602              bne     $FC19EA
FC19E8 4240              clr.w   D0
FC19EA 5200              addq.b  #1,D0            Drive select bit
FC19EC E308              lsl.b   #1,D0            Write in position
FC19EE 0A000007          eor.b   #7,D0            Invert for active low
FC19F2 6100026C          bsr     $FC1C60          Select drive
FC19F6 3039FFFF8604      move.w  $FFFF8604,D0     dskctl, read 1772 status
FC19FC 08000006          btst    #6,D0            Test write protect bit
FC1A00 56D0              sne     (A0)             and save
FC1A02 1002              move.b  D2,D0            Restore previous status
FC1A04 6100025A          bsr     $FC1C60
FC1A08 302D09B2          move.w  $9B2(A5),D0      wpstatus
FC1A0C 816D09B4          or.w    D0,$9B4(A5)      Write in wplatch
FC1A10 4A6D09C0          tst.w   $9C0(A5)         deslflg, floppies already deselected?
FC1A14 6618              bne     $FC1A2E          Yes
FC1A16 6100028C          bsr     $FC1CA4          Read 1772 status register
FC1A1A 08000007          btst    #7,D0            Motor-on bit set?
FC1A1E 6612              bne     $FC1A32          Yes, don't deselect
FC1A20 103C0007          move.b  #7,D0            Both drives
FC1A24 6100023A          bsr     $FC1C60          Deselect
FC1A28 3B7C000109C0      move.w  #1,$9C0(A5)      Set deslflg
FC1A2E 426D09BE          clr.w   $9BE(A5)         Clear motoron flag
```

```
FC1A32 4E75                  rts

**************************************************  floplock
FC1A34 48F978F8000009E2      movem.l D3-D7/A3-A6,$9E2    Save registers
FC1A3C 9BCD                  sub.l   A5,A5               Clear A5
FC1A3E 4DF9FFFF8606          lea     $FFFF8606,A6        Address of the floppy register
FC1A44 50F9000009BE          st      $9BE                Set motoron flag
FC1A4A 3B4009DE              move.w  D0,$9DE(A5)         deferror
FC1A4E 3B4009E0              move.w  D0,$9E0(A5)         currerr
FC1A52 3B7C0001043E          move.w  #1,$43E(A5)         flock, disable floppy VBL routine
FC1A58 2B6F000809CC          move.l  8(A7),$9CC(A5)      cdma, buffer address
FC1A5E 3B6F001009C2          move.w  16(A7),$9C2(A5)     cdev, drive
FC1A64 3B6F001209C6          move.w  18(A7),$9C6(A5)     csect, sector
FC1A6A 3B6F001409C4          move.w  20(A7),$9C4(A5)     ctrack, track
FC1A70 3B6F001609C8          move.w  22(A7),$9C8(A5)     cside, side
FC1A76 3B6F001809CA          move.w  24(A7),$9CA(A5)     ccount, number of sectors
FC1A7C 3B7C000209B0          move.w  #2,$9B0(A5)         retrycnt, 2 tries
FC1A82 43ED0A06              lea     $A06(A5),A1         Address dsb0
FC1A86 4A6D09C2              tst.w   $9C2(A5)            cdev, drive A?
FC1A8A 6704                  beq     $FC1A90             Yes
FC1A8C 43ED0A0A              lea     $A0A(A5),A1         else address dsb1
FC1A90 7E00                  moveq.l #0,D7
FC1A92 3E2D09CA              move.w  $9CA(A5),D7         ccount, number of sectors
FC1A96 E14F                  lsl.w   #8,D7
FC1A98 E34F                  lsl.w   #1,D7               times 512
FC1A9A 206D09CC              move.l  $9CC(A5),A0         cdma, start DMA address
FC1A9E D1C7                  add.l   D7,A0               plus sector length
FC1AA0 2B4809D0              move.l  A0,$9D0(A5)         edma, yields end DMA address
FC1AA4 4A690000              tst.w   (A1)                dcurtack, current track
FC1AA8 6A20                  bpl     $FC1ACA             Valid ?
FC1AAA 61000168              bsr     $FC1C14             select, select drive and side
FC1AAE 42690000              clr.w   (A1)                Track number to zero
```

```
FC1AB2 610000EC          bsr      $FC1BA0            restore, find track zero
FC1AB6 6712              beq      $FC1ACA            OK ?
FC1AB8 7E0A              moveq.l  #10,D7             Track 10
FC1ABA 6172              bsr      $FC1B2E            hseek, find track
FC1ABC 6606              bne      $FC1AC4            Error ?
FC1ABE 610000E0          bsr      $FC1BA0            restore, find track 0
FC1AC2 6706              beq      $FC1ACA            OK ?
FC1AC4 337CFF000000      move.w   #$FF00,(A1)        Track number invalid
FC1ACA 4E75              rts

*************************************************   flopfail, error in disk routine
FC1ACC 7001              moveq.l  #1,D0              media change to unsure
FC1ACE 61000226          bsr      $FC1CF6            set
FC1AD2 302D09E0          move.w   $9E0(A5),D0        currerr, error number
FC1AD6 48C0              ext.l    D0
FC1AD8 6002              bra      $FC1ADC

*************************************************   flopok, error-free disk routine
FC1ADA 4280              clr.l    D0                 Clear error number
FC1ADC 2F00              move.l   D0,-(A7)           Save error number
FC1ADE 3CBC0086          move.w   #$86,(A6)          Select 1772
FC1AE2 3E290000          move.w   (A1),D7            Get track number
FC1AE6 610001A8          bsr      $FC1C90            wdiskctl, D7 to 1772
FC1AEA 3C3C0010          move.w   #$10,D6            Seek command
FC1AEE 610000C6          bsr      $FC1BB6            flopcmds
FC1AF2 3039000009C2      move.w   $9C2,D0            cdev, drive number
FC1AF8 E548              lsl.w    #2,D0              times 4
FC1AFA 41F9000009B6      lea      $9B6,A0            acctim
FC1B00 21AD04BA0000      move.l   $4BA(A5),0(A0,D0.w)  _hz_200 as last access time
FC1B06 0C790001000004A6  cmp.w    #1,$4A6            _nflops
FC1B0E 6606              bne      $FC1B16            Only one drive?
FC1B10 216D04BA0004      move.l   $4BA(A5),4(A0)     _hz_200 as last access time
```

```
FC1B16 201F              move.l   (A7)+,D0                Error number
FC1B18 4CF978F8000009E2  movem.l  $9E2,D3-D7/A3-A6        Restore registers
FC1B20 42790000043E      clr.w    $43E                    flock, release floppy VBL routine
FC1B26 4E75              rts

***************************************************       hseek, find track
FC1B28 3E39000009C4      move.w   $9C4,D7                 ctrack, track number
FC1B2E 33FCFFFA000009E0  move.w   #-6,$9E0                Seek error, track not found
FC1B36 3CBC0086          move.w   #$86,(A6)               Select 1772
FC1B3A 61000154          bsr      $FC1C90                 wdiskctl, D7 to 1772
FC1B3E 3C3C0010          move.w   #$10,D6                 Seek command
FC1B42 60000072          bra      $FC1BB6                 flopcmds

***************************************************       reseek, home and seek
FC1B46 33FCFFFA000009E0  move.w   #-6,$9E0                Seek error, track not found
FC1B4E 6150              bsr      $FC1BA0                 Restore
FC1B50 664C              bne      $FC1B9E                 Error ?
FC1B52 42690000          clr.w    (A1)                    Track number to zero
FC1B56 3CBC0082          move.w   #$82,(A6)               Select track register
FC1B5A 4247              clr.w    D7                      Track zero
FC1B5C 61000132          bsr      $FC1C90                 wdiskctl, D7 to 1772
FC1B60 3CBC0086          move.w   #$86,(A6)               Select data register
FC1B64 3E3C0005          move.w   #5,D7                   Track 5
FC1B68 61000126          bsr      $FC1C90                 wdiskctl, D7 to 1772
FC1B6C 3C3C0010          move.w   #$10,D6                 Seek command
FC1B70 6144              bsr      $FC1BB6                 flopcmds
FC1B72 662A              bne      $FC1B9E                 Error ?
FC1B74 337C00050000      move.w   #5,(A1)                 Track number to 5

***************************************************       go2track, find track
FC1B7A 33FCFFFA000009E0  move.w   #-6,$9E0                Seek error, track not found
FC1B82 3CBC0086          move.w   #$86,(A6)               Select data register
```

```
FC1B86 3E2D09C4           move.w  $9C4(A5),D7          Track number
FC1B8A 61000104           bsr     $FC1C90              wdiskctl, D7 to 1772
FC1B8E 7C14               moveq.l #$14,D6              Seek with verify command
FC1B90 6124               bsr     $FC1BB6              flopcmds
FC1B92 660A               bne     $FC1B9E              Error ?
FC1B94 336D09C40000       move.w  $9C4(A5),(A1)        Save track number
FC1B9A CE3C0018           and.b   #$18,D7              Test RNF, CRC, Lost Data
FC1B9E 4E75               rts

*****************************************************  restore, find track zero
FC1BA0 4246               clr.w   D6                   Restore command
FC1BA2 6112               bsr     $FC1BB6              flopcmds
FC1BA4 660E               bne     $FC1BB4              Error ?
FC1BA6 08070002           btst    #2,D7                Test track-zero bit
FC1BAA 0A3C0004           eor.b   #4,SR                Invert Z-flag
FC1BAE 6604               bne     $FC1BB4              Not track zero?
FC1BB0 42690000           clr.w   (A1)                 Track number to zero
FC1BB4 4E75               rts

*****************************************************  flopcmds
FC1BB6 30290002           move.w  2(A1),D0             Seek rate
FC1BBA C03C0003           and.b   #3,D0                Bits 0 and 1
FC1BBE 8C00               or.b    D0,D6                OR with command word
FC1BC0 2E3C00040000       move.l  #$40000,D7           Timeout counter
FC1BC6 3CBC0080           move.w  #$80,(A6)            Select 1772
FC1BCA 610000D8           bsr     $FC1CA4              rdiskctl
FC1BCE 08000007           btst    #7,D0                Motor on ?
FC1BD2 6606               bne     $FC1BDA              Yes
FC1BD4 2E3C00060000       move.l  #$60000,D7           Else longer timeout
FC1BDA 610000AA           bsr     $FC1C86              wdiskctl6, write command in D6
FC1BDE 5387               subq.l  #1,D7                Decrement timeout counter
FC1BE0 6712               beq     $FC1BF4              Run out?
```

```
FC1BE2 08390005FFFFFA01     btst     #5,$FFFFFA01      mfp gpip, disk done?
FC1BEA 66F2                 bne      $FC1BDE           No, wait
FC1BEC 610000AC             bsr      $FC1C9A           rdiskctl7, read status
FC1BF0 4246                 clr.w    D6                OK
FC1BF2 4E75                 rts

FC1BF4 6104                 bsr      $FC1BFA           Reset 1772
FC1BF6 7C01                 moveq.l #1,D6              Error
FC1BF8 4E75                 rts       ¿n1¡¿a3¡

************************************************       Reset 1772, Reset Floppy Controller
FC1BFA 3CBC0080             move.w   #$80,(A6)         Select command register
FC1BFE 3E3C00D0             move.w   #$D0,D7           Reset command
FC1C02 6100008C             bsr      $FC1C90           wdiskctl, D7 to 1772
FC1C06 3E3C000F             move.w   #$F,D7            Delay counter
FC1C0A 51CFFFFE             dbra     D7,$FC1C0A        Time run out?
FC1C0E 6100008A             bsr      $FC1C9A           rdiskctl, read status
FC1C12 4E75                 rts

************************************************       select, select drive and side
FC1C14 426D09C0             clr.w    $9C0(A5)          Clear deslflg
FC1C18 302D09C2             move.w   $9C2(A5),D0       cdev, drive number
FC1C1C 5200                 addq.b   #1,D0
FC1C1E E308                 lsl.b    #1,D0             Calculate bit number
FC1C20 806D09C8             or.w     $9C8(A5),D0       csid, side in bit 0
FC1C24 0A000007             eor.b    #7,D0             Invert bits for active low
FC1C28 C03C0007             and.b    #7,D0
FC1C2C 6132                 bsr      $FC1C60           setporta, set bits
FC1C2E 3CBC0082             move.w   #$82,(A6)         Select track register
FC1C32 3E290000             move.w   (A1),D7           Get track number
FC1C36 6158                 bsr      $FC1C90           wdiskctl, D7 to 1772
FC1C38 422D09DA             clr.b    $9DA(A5)          tmpdma, clear bits 24-31
```

```
FC1C3C 3CBC0084            move.w  #$84,(A6)            Select sector register
FC1C40 3E2D09C6            move.w  $9C6(A5),D7          csect, get sector number
FC1C44 614A                bsr     $FC1C90              wdiskctl, D7 to 1772
FC1C46 13ED09CFFFFF860D    move.b  $9CF(A5),$FFFF860D
FC1C4E 13ED09CEFFFF860B    move.b  $9CE(A5),$FFFF860B   Set DMA address
FC1C56 13ED09CDFFFF8609    move.b  $9CD(A5),$FFFF8609
FC1C5E 4E75                rts

*****************************************************   setporta, select drive and side
FC1C60 40E7                move.w  SR, -(A7)            Save status
FC1C62 007C0700            or.w    #$700,SR             IPL 7, no interrupts
FC1C66 13FC000EFFFF8800    move.b  #$E,$FFFF8800        Select port A
FC1C6E 1239FFFF8800        move.b  $FFFF8800,D1         Read data from port
FC1C74 1401                move.b  D1,D2                and save
FC1C76 C23C00F8            and.b   #$F8,D1              Clear bits 0-2
FC1C7A 8200                or.b    D0,D1                Set new bits
FC1C7C 13C1FFFF8802        move.b  D1,$FFFF8802         Write result in port A
FC1C82 46DF                move.w  (A7)+,SR             Reset status
FC1C84 4E75                rts

*****************************************************   wdiskct6
FC1C86 6124                bsr     $FC1CAC              Delay loop for disk controller
FC1C88 33C6FFFF8604        move.w  D6,$FFFF8604         D6  to disk controller
FC1C8E 601C                bra     $FC1CAC              Delay loop for disk controller

*****************************************************   wdiskctl
FC1C90 611A                bsr     $FC1CAC              Delay loop for disk controller
FC1C92 33C7FFFF8604        move.w  D7,$FFFF8604         D7 to disk controller
FC1C98 6012                bra     $FC1CAC              Delay loop for disk controller
```

```
*******************************************************  rdiskct7
FC1C9A 6110              bsr     $FC1CAC                 Delay loop for disk controller
FC1C9C 3E39FFFF8604      move.w  $FFFF8604,D7            Disk controller status to D7
FC1CA2 6008              bra     $FC1CAC                 Delay loop for disk controller

*******************************************************  rdiskctl
FC1CA4 6106              bsr     $FC1CAC                 Delay loop for disk controller
FC1CA6 3039FFFF8604      move.w  $FFFF8604,D0            Disk controller status to D0
FC1CAC 40E7              move.w  SR, -(A7)               Save status
FC1CAE 3F07              move.w  D7,-(A7)                Save D7
FC1CB0 3E3C0020          move.w  #$20,D7                 Counter
FC1CB4 51CFFFFE          dbra    D7,$FC1CB4              Delay loop
FC1CB8 3E1F              move.w  (A7)+,D7                D7 back
FC1CBA 46DF              move.w  (A7)+,SR                Status back
FC1CBC 4E75              rts

*******************************************************  change, test for disk change
FC1CBE 0C790001000004A6  cmp.w   #1,$4A6                 _nflops
FC1CC6 662C              bne     $FC1CF4                 0 or 2 drives, done
FC1CC8 302F0010          move.w  16(A7),D0               Drive number
FC1CCC B07900005622      cmp.w   $5622,D0                Same disk number?
FC1CD2 671C              beq     $FC1CF0                 Yes
FC1CD4 3F00              move.w  D0,-(A7)                Drive number
FC1CD6 3F3CFFEF          move.w  #-17,-(A7)              'Insert Disk'
FC1CDA 6100EA62          bsr     $FC073E                 Critical error handler
FC1CDE 584F              addq.w  #4,A7                   Correct stack pointer
FC1CE0 33FCFFFF000009B4  move.w  #-1,$9B4                wplatch, status unsure
FC1CE8 33EF001000005622  move.w  16(A7),$5622            Save disk number
FC1CF0 426F0010          clr.w   16(A7)                  Drive number to zero
FC1CF4 4E75              rts
```

```
*****************************************************   setdmode, set Drive Change Mode
FC1CF6 41F900004DB8      lea      $4DB8,A0            Address of the bpb
FC1CFC 1F00              move.b   D0,-(A7)            Save mode
FC1CFE 302D09C2          move.w   $9C2(A5),D0         cdev, get drive number
FC1D02 119F0000          move.b   (A7)+,0(A0,D0.w)    Set drive mode
FC1D06 4E75              rts

*****************************************************   dskf, disk flags
FC1D08 AE                dc.b     $AE
FC1D09 D6                dc.b     $D6
FC1D0A 8C                dc.b     $8C
FC1D0B 17                dc.b     $17
FC1D0C FB                dc.b     $FB
FC1D0D 80                dc.b     $80
FC1D0E 6A                dc.b     $6A
FC1D0F 2B                dc.b     $2B
FC1D10 A6                dc.b     $A6
FC1D11 00                dc.b     $00

*****************************************************   Jdostime, IKBD format to DOS format
FC1D12 4BF900000000      lea      $0,A5               Clear A5
FC1D18 41ED0E01          lea      $E01(A5),A0         Pointer to clock-time buffer
FC1D1C 610000DE          bsr      $FC1DFC             bcdbin
FC1D20 04000050          sub.b    #80,D0              Subtract offset of 80
FC1D24 1400              move.b   D0,D2               Year
FC1D26 E982              asl.l    #4,D2               Write in position
FC1D28 610000D2          bsr      $FC1DFC             bcdbin
FC1D2C D400              add.b    D0,D2               Add month
FC1D2E EB82              asl.l    #5,D2               Write in position
```

```
FC1D30 610000CA         bsr      $FC1DFC          bcdbin
FC1D34 D400             add.b    D0,D2            Add day
FC1D36 EB82             asl.l    #5,D2            Write in position
FC1D38 610000C2         bsr      $FC1DFC          bcdbin
FC1D3C D400             add.b    D0,D2            Add hour
FC1D3E ED82             asl.l    #6,D2            Write in position
FC1D40 610000BA         bsr      $FC1DFC          bcdbin
FC1D44 D400             add.b    D0,D2            Add minute
FC1D46 EB82             asl.l    #5,D2            Write in position
FC1D48 610000B2         bsr      $FC1DFC          bcdbin
FC1D4C E208             lsr.b    #1,D0            2-second resolution
FC1D4E D400             add.b    D0,D2            Add seconds
FC1D50 2B420E0A         move.l   D2,$E0A(A5)      Save new time
FC1D54 1B7C00000E4C     move.b   #0,$E4C(A5)      Clear handshake flag
FC1D5A 4E75             rts

*****************************************************  gettime, get current time and date
FC1D5C 1B7CFFFF0E4C     move.b   #-1,$E4C(A5)     Set handshake flag
FC1D62 123C001C         move.b   #$1C,D1          Get time of day command
FC1D66 61000240         bsr      $FC1FA8          Send to IKBD
FC1D6A 4A2D0E4C         tst.b    $E4C(A5)         New time arrived?
FC1D6E 66FA             bne      $FC1D6A          No, wait
FC1D70 202D0E0A         move.l   $E0A(A5),D0      Put time in D0
FC1D74 4E75             rts

*****************************************************  settime, set time and data
FC1D76 2B6F00040E0E     move.l   4(A7),$E0E(A5)   Pass time

*****************************************************  ikbdtime
FC1D7C 41F900000E18     lea      $E18,A0          Pointer to end of time buffer
```

```
FC1D82 242D0E0E     move.l  $E0E(A5),D2     Get time to convert
FC1D86 1002         move.b  D2,D0           in D0
FC1D88 0200001F     and.b   #$1F,D0         Bits 0-4, seconds
FC1D8C E300         asl.b   #1,D0           2-second resolution
FC1D8E 6154         bsr     $FC1DE4         convert
FC1D90 EA8A         lsr.l   #5,D2           Minutes
FC1D92 1002         move.b  D2,D0
FC1D94 0200003F     and.b   #$3F,D0         Bits 0-5
FC1D98 614A         bsr     $FC1DE4         convert
FC1D9A EC8A         lsr.l   #6,D2           Hours
FC1D9C 1002         move.b  D2,D0
FC1D9E 0200001F     and.b   #$1F,D0         Bits 0-4
FC1DA2 6140         bsr     $FC1DE4         convert
FC1DA4 EA8A         lsr.l   #5,D2           Day
FC1DA6 1002         move.b  D2,D0
FC1DA8 0200001F     and.b   #$1F,D0         Bits 0-4
FC1DAC 6136         bsr     $FC1DE4         convert
FC1DAE EA8A         lsr.l   #5,D2           Month
FC1DB0 1002         move.b  D2,D0
FC1DB2 0200000F     and.b   #$F,D0          Bits 0-3
FC1DB6 612C         bsr     $FC1DE4         convert
FC1DB8 E88A         lsr.l   #4,D2           Year
FC1DBA 1002         move.b  D2,D0
FC1DBC 0200007F     and.b   #$7F,D0         Bits 0-6
FC1DC0 6122         bsr     $FC1DE4         convert
FC1DC2 06100080     add.b   #$80,(A0)       Add offset
FC1DC6 123C001B     move.b  #$1B,D1         Set time of day command
FC1DCA 610001DC     bsr     $FC1FA8         Send to IKBD
```

```
FC1DCE 7605            moveq.l #5,D3          Number of bytes minus 1
FC1DD0 45F900000E12    lea     $E12,A2        Address of the string
FC1DD6 610001F0        bsr     $FC1FC8        ikbdws, send string
FC1DDA 123C001C        move.b  #$1C,D1        Get time of day command
FC1DDE 610001C8        bsr     $FC1FA8        Send to IKBD
FC1DE2 4E75            rts

*************************************************   binbcd, convert byte to BCD
FC1DE4 7200            moveq.l #0,D1          Ten's counter
FC1DE6 760A            moveq.l #10,D3
FC1DE8 9003            sub.b   D3,D0          Subtract 10
FC1DEA 6B04            bmi     $FC1DF0
FC1DEC 5201            addq.b  #1,D1          Increment ten's counter
FC1DEE 60F8            bra     $FC1DE8
FC1DF0 0600000A        add.b   #10,D0         Generate one's place
FC1DF4 E901            asl.b   #4,D1          Tens in upper nibble
FC1DF6 D001            add.b   D1,D0          plus ones
FC1DF8 1100            move.b  D0,-(A0)       Write in buffer
FC1DFA 4E75            rts

*************************************************   bcdbin, convert BCD to binary
FC1DFC 7000            moveq.l #0,D0
FC1DFE 1010            move.b  (A0),D0        BCD byte
FC1E00 E808            lsr.b   #4,D0          Tens place
FC1E02 E308            lsl.b   #1,D0          times 2
FC1E04 1200            move.b  D0,D1
FC1E06 E500            asl.b   #2,D0          times 4
FC1E08 D001            add.b   D1,D0
FC1E0A 1218            move.b  (A0)+,D1       One's place
```

```
FC1E0C 0241000F          and.w    #$F,D1         isolate
FC1E10 D041              add.w    D1,D0          and add
FC1E12 4E75              rts

*****************************************************  midiost, MIDI output status
FC1E14 70FF              moveq.l #-1,D0          Default to OK
FC1E16 1439FFFFFC04      move.b   $FFFFFC04,D2   Read MIDI ACIA status
FC1E1C 08020001          btst     #1,D2          and test
FC1E20 6602              bne      $FC1E24        OK
FC1E22 7000              moveq.l #0,D0           Not OK, ACIA is sending
FC1E24 4E75              rts

*****************************************************  midiwc, output character to MIDI
FC1E26 322F0006          move.w   6(A7),D1       Get character
FC1E2A 43F9FFFFFC04      lea      $FFFFFC04,A1   MIDI ACIA control
FC1E30 14290000          move.b   (A1),D2        Get MIDI status
FC1E34 08020001          btst     #1,D2          OK ?
FC1E38 67F6              beq      $FC1E30        No, wait
FC1E3A 13410002          move.b   D1,2(A1)       Output byte
FC1E3E 4E75              rts

*****************************************************  midiws, send string to MIDI
FC1E40 7600              moveq.l #0,D3           (unnecessary!)
FC1E42 362F0004          move.w   4(A7),D3       Length of the string - 1
FC1E46 246F0006          move.l   6(A7),A2       Address of the string
FC1E4A 121A              move.b   (A2)+,D1       Get byte
FC1E4C 61DC              bsr      $FC1E2A        and send
FC1E4E 51CBFFFA          dbra     D3,$FC1E4A     Next byte
FC1E52 4E75              rts
```

```
********************************************************  midstat, MIDI receiver status
FC1E54 41ED0DBE          lea       $DBE(A5),A0        iorec for MIDI
FC1E58 43F9FFFFFC04      lea       $FFFFFC04,A1       MIDI ACIA control
FC1E5E 70FF              moveq.l   #-1,D0             Default to OK
FC1E60 45E80006          lea       6(A0),A2           Head index
FC1E64 47E80008          lea       8(A0),A3           Tail index
FC1E68 B54B              cmpm.w    (A3)+,(A2)+        Characters in buffer?
FC1E6A 6602              bne       $FC1E6E            Yes
FC1E6C 7000              moveq.l   #0,D0              Character ready
FC1E6E 4E75              rts

********************************************************  midin, get character from MIDI
FC1E70 61E2              bsr       $FC1E54            midstat, character ready?
FC1E72 4A40              tst.w     D0
FC1E74 67FA              beq       $FC1E70            No, wait
FC1E76 40E7              move.w    SR, -(A7)          Save status
FC1E78 007C0700          or.w      #$700,SR           IPL 7, disable interrupts
FC1E7C 32280006          move.w    6(A0),D1           Head index
FC1E80 B2680008          cmp.w     8(A0),D1           Compare with tail index
FC1E84 6716              beq       $FC1E9C            Buffer empty
FC1E86 5241              addq.w    #1,D1              Increment head index
FC1E88 B2680004          cmp.w     4(A0),D1           Larger buffer size?
FC1E8C 6502              bcs       $FC1E90            No
FC1E8E 7200              moveq.l   #0,D1              Start again beginning of buffer
FC1E90 22680000          move.l    (A0),A1            Buffer address
FC1E94 10311000          move.b    0(A1,D1.w),D0      Get character from buffer
FC1E98 31410006          move.w    D1,6(A0)           Save new head index
FC1E9C 46DF              move.w    (A7)+,SR           Get status
FC1E9E 4E75              rts
```

```
******************************************************  lstout, printer output
FC1EA0 082D00040E4A     btst     #4,$E4A(A5)            RS 232 printer?
FC1EA6 660000DE         bne      $FC1F86                Yes, output to RS 232
FC1EAA 242D04BA         move.l   $4BA(A5),D2            _hz_200, 200 Hz counter
FC1EAE 94AD0E3E         sub.l    $E3E(A5),D2            minus last time
FC1EB2 0C82000003E8     cmp.l    #1000,D2               Less than 10 seconds
FC1EB8 6518             bcs      $FC1ED2                Yes
FC1EBA 242D04BA         move.l   $4BA(A5),D2            _hz_200
FC1EBE 6174             bsr      $FC1F34                lstostat, printer ready?
FC1EC0 4A40             tst.w    D0
FC1EC2 6618             bne      $FC1EDC                Yes, output character
FC1EC4 262D04BA         move.l   $4BA(A5),D3            _hz_200, 200 Hz counter
FC1EC8 9682             sub.l    D2,D3                  minus last time
FC1ECA 0C8300001770     cmp.l    #6000,D3               More than 30 seconds?
FC1ED0 6DEC             blt      $FC1EBE                No, wait
FC1ED2 7000             moveq.l #0,D0                   Character not sent
FC1ED4 2B6D04BA0E3E     move.l   $4BA(A5),$E3E(A5)      Save _hz_200 as new time
FC1EDA 4E75             rts

******************************************************  Output character to parallel port
FC1EDC 40C3             move.w   SR, D3                 Save status
FC1EDE 007C0700         or.w     #$700,SR               IPL 7, no interrupts
FC1EE2 7207             moveq.l #7,D1                   Register 7
FC1EE4 61000E6E         bsr      $FC2D54                select
FC1EE8 00000080         or.b     #$80,D0                Port B
FC1EEC 7287             moveq.l #$87,D1                 Write register 7
FC1EEE 61000E64         bsr      $FC2D54                Port B to output
FC1EF2 46C3             move.w   D3,SR                  Save status
FC1EF4 302F0006         move.w   6(A7),D0               Character to output
FC1EF8 728F             moveq.l #$8F,D1                 Write port B
```

```
FC1EFA 61000E58        bsr      $FC2D54          Output character
FC1EFE 610E            bsr      $FC1F0E          Strobe low
FC1F00 610C            bsr      $FC1F0E          Strobe low
FC1F02 6104            bsr      $FC1F08          Strobe high
FC1F04 70FF            moveq.l #-1,D0            OK
FC1F06 4E75            rts

*******************************************************  Strobe high
FC1F08 7420            moveq.l #$20,D2           Bit 5
FC1F0A 60000E8A        bra      $FC2D96          set in port A

*******************************************************  Strobe low
FC1F0E 74DF            moveq.l #$DF,D2           Bit 5
FC1F10 60000EAA        bra      $FC2DBC          clear in port A

*******************************************************  lstin, get character from parallel port
FC1F14 7207            moveq.l #7,D1             Mixer
FC1F16 61000E3C        bsr      $FC2D54          Select register in PSG
FC1F1A 0200007F        and.b    #$7F,D0          Port B to input
FC1F1E 7287            moveq.l #$87,D1           Write register 7
FC1F20 61000E32        bsr      $FC2D54          giacces
FC1F24 61E2            bsr      $FC1F08          Strobe high = receiver ready
FC1F26 610C            bsr      $FC1F34          lstostat, character arrived?
FC1F28 4A40            tst.w    D0
FC1F2A 66FA            bne      $FC1F26          No, wait
FC1F2C 61E0            bsr      $FC1F0E          Strobe low = receiver busy
```

```
FC1F2E 720F              moveq.l #15,D1             Select port B
FC1F30 60000E22          bra     $FC2D54            Read byte from port

******************************************************* lstostat, printer output status
FC1F34 41F9FFFFFA01      lea     $FFFFFA01,A0       mfp gpip
FC1F3A 70FF              moveq.l #-1,D0             Default to ok
FC1F3C 082800000000      btst    #0,(A0)            Busy to low ?
FC1F42 6702              beq     $FC1F46            Yes
FC1F44 7000              moveq.l #0,D0              Printer not ready
FC1F46 4E75              rts

******************************************************* auxistat, RS 232 input status
FC1F48 41ED0D8E          lea     $D8E(A5),A0        iorec for rs232
FC1F4C 70FF              moveq.l #-1,D0             Default to OK
FC1F4E 45E80006          lea     6(A0),A2           Head index
FC1F52 47E80008          lea     8(A0),A3           Tail index
FC1F56 B54B              cmpm.w  (A3)+,(A2)+        Buffer empty?
FC1F58 6602              bne     $FC1F5C            No
FC1F5A 7000              moveq.l #0,D0              No characters ready
FC1F5C 4E75              rts

******************************************************* auxin, RS 232 input
FC1F5E 61E8              bsr     $FC1F48            auxistat, character ready?
FC1F60 4A40              tst.w   D0
FC1F62 67FA              beq     $FC1F5E            No, wait
FC1F64 610005D6          bsr     $FC253C            rs232get, get character
```

```
FC1F68 024000FF        and.w    #$FF,D0           Isolate bits 0-7
FC1F6C 4E75            rts

**************************************************  auxostat, RS 232 output status
FC1F6E 41ED0D8E        lea      $D8E(A5),A0       iorec for RS 232
FC1F72 70FF            moveq.l  #-1,D0            Default to OK
FC1F74 34280016        move.w   22(A0),D2         Tail index
FC1F78 61000896        bsr      $FC2810           Test for wrap around
FC1F7C B4680014        cmp.w    20(A0),D2         Compare with head index
FC1F80 6602            bne      $FC1F84           OK
FC1F82 7000            moveq.l  #0,D0             No space in buffer
FC1F84 4E75            rts

**************************************************  auxout, RS 232 output
FC1F86 322F0006        move.w   6(A7),D1          Get byte
FC1F8A 61000554        bsr      $FC24E0           rs232put, write in buffer
FC1F8E 65F6            bcs      $FC1F86           Not sent, try again
FC1F90 4E75            rts

**************************************************  ikbdost, IKBD output status
FC1F92 70FF            moveq.l  #-1,D0            Default to ok
FC1F94 1439FFFFFC00    move.b   $FFFFFC00,D2      Keyboard ACIA status
FC1F9A 08020001        btst     #1,D2             ACIA ready ?
FC1F9E 6602            bne      $FC1FA2           Yes
FC1FA0 7000            moveq.l  #0,D0             Not used
FC1FA2 4E75            rts

**************************************************  ikbdwc, send byte to IKBD
FC1FA4 322F0006        move.w   6(A7),D1          Get byte
FC1FA8 43F9FFFFFC00    lea      $FFFFFC00,A1      Keyboard ACIA control
FC1FAE 14290000        move.b   (A1),D2           Get ACIA status
FC1FB2 08020001        btst     #1,D2             Ready?
```

```
FC1FB6 67F6          beq      $FC1FAE           No, wait
FC1FB8 13410002      move.b   D1,2(A1)          Send byte
FC1FBC 4E75          rts

*******************************************     ikbdws, send string to keyboard
FC1FBE 7600          moveq.l #0,D3              unnecessary!
FC1FC0 362F0004      move.w   4(A7),D3          Number of characters minus 1
FC1FC4 246F0006      move.l   6(A7),A2          Address of the string
FC1FC8 121A          move.b   (A2)+,D1          Get byte
FC1FCA 61DC          bsr      $FC1FA8           Send to keyboard
FC1FCC 51CBFFFA      dbra     D3,$FC1FC8        Next byte
FC1FD0 4E75          rts

*******************************************     constat, keybaord input status
FC1FD2 41ED0DB0      lea      $DB0(A5),A0       iorec for keyboard
FC1FD6 70FF          moveq.l #-1,D0             Default for OK
FC1FD8 45E80006      lea      6(A0),A2          Head index
FC1FDC 47E80008      lea      8(A0),A3          Tail index
FC1FE0 B54B          cmpm.w   (A3)+,(A2)+       Buffer empty?
FC1FE2 6602          bne      $FC1FE6           No, OK
FC1FE4 7000          moveq.l #0,D0              No characters there
FC1FE6 4E75          rts

*******************************************     conin, get character from keyboard
FC1FE8 61E8          bsr      $FC1FD2           constat, key pressed?
FC1FEA 4A40          tst.w    D0
FC1FEC 67FA          beq      $FC1FE8           No, wait
FC1FEE 40E7          move.w   SR, -(A7)         Save status
FC1FF0 007C0700      or.w     #$700,SR          IPL 7, disable interrupts
FC1FF4 32280006      move.w   6(A0),D1          Head index
FC1FF8 B2680008      cmp.w    8(A0),D1          Compare with tail index
FC1FFC 6716          beq      $FC2014           Buffer empty?
```

```
FC1FFE 5841                addq.w   #4,D1                   Increment head index
FC2000 B2680004            cmp.w    4(A0),D1                Greater or equal to buffer size?
FC2004 6502                bcs      $FC2008                 No
FC2006 7200                moveq.l  #0,D1                   Buffer point back to start
FC2008 22680000            move.l   (A0),A1                 Buffer address
FC200C 20311000            move.l   0(A1,D1.w),D0           Get character
FC2010 31410006            move.w   D1,6(A0)                Save new head index
FC2014 46DF                move.w   (A7)+,SR                Get status
FC2016 4E75                rts

*********************************************************   conoutst, console output status
FC2018 70FF                moveq.l  #-1,D0                  Status always OK
FC201A 4E75                rts

*********************************************************   ringbel, tone after CTRL G
FC201C 082D00020484        btst     #2,$484(A5)             conterm, sound enabled ?
FC2022 670E                beq      $FC2032                 No
FC2024 2B7C00FC30760E44    move.l   #$FC3076,$E44(A5)       Pointer to sound table for ell
FC202C 1B7C00000E48        move.b   #0,$E48(A5)             Start sound timer
FC2032 4E75                rts

*********************************************************   Keyboard table, unshifted
FC2034 001B313233343536    dc.b     $00,esc,'1','2','3','4','5','6'
FC203C 373839309E270809    dc.b     '7','8','9','0','û',''',bs, tab
FC2044 71776572747A7569    dc.b     'q','w','e','r','t','z','u','i'
FC204C 6F70812B0D006173    dc.b     'o','p','Å','+',cr, $00,'a','s'
FC2054 646667686A6B6C94    dc.b     'd','f','g','h','j','k','l','î'
FC205C 8423007E79786376    dc.b     'Ñ','#',$00,'~','y','x','c','v'
FC2064 626E6D2C2E2D0000    dc.b     'b','n','m',',','.','-',$00,$00
FC206C 0020000000000000    dc.b     $00,' ',$00,$00,$00,$00,$00,$00
FC2074 0000000000000000    dc.b     $00,$00,$00,$00,$00,$00,$00,$00
FC207C 00002D0000002B00    dc.b     $00,$00,'-',$00,$00,$00,'+',$00
```

```
FC2084 0000007F00000000     dc.b    $00,$00,$00,del,$00,$00,$00,$00
FC208C 0000000000000000     dc.b    $00,$00,$00,$00,$00,$00,$00,$00
FC2094 3C000028292F2A37     dc.b    '<',$00,$00,'(',')','/','*','7'
FC209C 3839343536313233     dc.b    '8','9','4','5','6','1','2','3'
FC20A4 302E0D0000000000     dc.b    '0','.',cr, $00,$00,$00,$00,$00
FC20AC 0000000000000000     dc.b    $00,$00,$00,$00,$00,$00,$00,$00
*********************************************************  Keyboard table, shifted
FC20B4 001B2122DD242526     dc.b    $00,esc,'!','"','›','$','%','&'
FC20BC 2F28293D3F600809     dc.b    '/','(',')','=','?','`',bs, tab
FC20C4 51574552545A5549     dc.b    'Q','W','E','R','T','Z','U','I'
FC20CC 4F509A2A0D004153     dc.b    'O','P','ö','*',cr, $00,'A','S'
FC20D4 444647484A4B4C99     dc.b    'D','F','G','H','J','K','L','ô'
FC20DC 8E5E007C59584356     dc.b    'é','^',$00,'|','Y','X','C','V'
FC20E4 424E4D3B3A5F0000     dc.b    'B','N','M',';',':','_',$00,$00
FC20EC 0020000000000000     dc.b    $00,' ',$00,$00,$00,$00,$00,$00
FC20F4 0000000000000037     dc.b    $00,$00,$00,$00,$00,$00,$00,'7'
FC20FC 38002D3400362B00     dc.b    '8',$00,'-','4',$00,'6','+',$00
FC2104 3200307F00000000     dc.b    '2',$00,'0',del,$00,$00,$00,$00
FC210C 0000000000000000     dc.b    $00,$00,$00,$00,$00,$00,$00,$00
FC2114 3E000028292F2A37     dc.b    '>',$00,$00,'(',')','/','*'.'7'
FC211C 3839343536313233     dc.b    '8','9','4','5','6','1','2','3'
FC2124 302E0D0000000000     dc.b    '0','.',cr, $00,$00,$00,$00,$00
FC212C 0000000000000000     dc.b    $00,$00,$00,$00,$00,$00,$00,$00
*********************************************************  Keyboard table, Caps lock
FC2134 001B313233343536     dc.b    $00,esc,'1','2','3','4','5','6'
FC213C 373839309E270809     dc.b    '7','8','9','0','û',''',bs, tab
FC2144 51574552545A5549     dc.b    'Q','W','E','R','T','Z','U','I'
FC214C 4F509A2B0D004153     dc.b    'O','P','ö','+',cr, $00,'A','S'
FC2154 444647484A4B4C99     dc.b    'D','F','G','H','J','K','L','ô'
FC215C 8E23007E59584356     dc.b    'é','#',$00,'~','Y','X','C','V'
FC2164 424E4D2C2E2D0000     dc.b    'B','N','M',',','.','-',$00,$00
FC216C 0020000000000000     dc.b    $00,' ',$00,$00,$00,$00,$00,$00
```

```
FC2174 0000000000000000     dc.b    $00,$00,$00,$00,$00,$00,$00,$00
FC217C 00002D0000002B00     dc.b    $00,$00,'-',$00,$00,$00,'+',$00
FC2184 0000007F00000000     dc.b    $00,$00,$00,del,$00,$00,$00,$00
FC218C 0000000000000000     dc.b    $00,$00,$00,$00,$00,$00,$00,$00
FC2194 3C000028292F2A37     dc.b    '<',$00,$00,'(',')','/','*','7'
FC219C 3839343536313233     dc.b    '8','9','4','5','6','1','2','3'
FC21A4 302E0D0000000000     dc.b    '0','.',$00,$00,$00,$00,$00,$00
FC21AC 0000000000000000     dc.b    $00,$00,$00,$00,$00,$00,$00,$00

*****************************************************  initmfp, initialize MFP 68901
FC21B4 41F9FFFFFA01         lea     $FFFFFA01,A0       Address of mfp
FC21BA 7000                 moveq.l #0,D0              Initialize register with zero
FC21BC 01C80000             movep.l D0,0(A0)           gpip to iera
FC21C0 01C80008             movep.l D0,8(A0)           ierb to isra
FC21C4 01C80010             movep.l D0,16(A0)          isrb to vr
FC21C8 117C00480016         move.b  #$48,22(A0)        MFP non-autovector number to $40, set S-bit
FC21CE 3B7C11110E42         move.w  #$1111,$E42(A5)    Timer C bit map to every 4th IRQ
FC21D4 3B7C00140442         move.w  #$14,$442(A5)      _timer_ms to 20 ms
FC21DA 7002                 moveq.l #2,D0              Select timer C
FC21DC 7250                 moveq.l #80,D1             /64 for 200 Hz
FC21DE 343C00C0             move.w  #$C0,D2            192
FC21E2 61000182             bsr     $FC2366            Initialize timer and interrupt vector
FC21E6 45F900FC2F78         lea     $FC2F78,A2         Timer C interrupt routine
FC21EC 7005                 moveq.l #5,D0              Timer C interrupt number
FC21EE 6100022C             bsr     $FC241C            initint, initialize interrupt
FC21F2 7003                 moveq.l #3,D0              Select timer D
FC21F4 7201                 moveq.l #1,D1              /4 for 9600 baud
FC21F6 7402                 moveq.l #2,D2              9600 baud
FC21F8 6100016C             bsr     $FC2366            Initialize timer and interrupt vector
FC21FC 203C00980101         move.l  #$980101,D0        $00, $98, $01, $01
FC2202 01C80026             movep.l D0,$26(A0)         to scr, ucr, rsr, tsr
FC2206 61000B84             bsr     $FC2D8C            DTR on
```

```
FC220A 61000B78          bsr      $FC2D84             RTS on
FC220E 41ED0D8E          lea      $D8E(A5),A0         Pointer to iorec for RS 232
FC2212 43F900FC2334      lea      $FC2334,A1          Start data for iorec
FC2218 7021              moveq.l  #33,D0              34 bytes
FC221A 610000F0          bsr      $FC230C             Copy to RAM
FC221E 41ED0DBE          lea      $DBE(A5),A0         Pointer to iorec for MIDI
FC2222 43F900FC2326      lea      $FC2326,A1          Start data for iorec
FC2228 700D              moveq.l  #13,D0              14 bytes
FC222A 610000E0          bsr      $FC230C             Copy to RAM
FC222E 203C00FC288E      move.l   #$FC288E,D0         Keyboard and MIDI error vector
FC2234 2B400DD0          move.l   D0,$DD0(A5)         Pointer to keyboard error routine
FC2238 2B400DD4          move.l   D0,$DD4(A5)         Pointer to MIDI error routine
FC223C 2B7C00FC2CE20DCC  move.l   #$FC2CE2,$DCC(A5)   sysmidi vector
FC2244 2B7C00FC284A0DE8  move.l   #$FC284A,$DE8(A5)   midisys vector
FC224C 2B7C00FC285A0DEC  move.l   #$FC285A,$DEC(A5)   ikbdsys vector
FC2254 13FC0003FFFFFC04  move.b   #3,$FFFFFC04        MIDI ACIA control, master reset
FC225C 13FC0095FFFFFC04  move.b   #$95,$FFFFFC04      /16, 8 Bit, 1 stop bit, no parity
FC2264 1B7C00070484      move.b   #7,$484(A5)         conterm, keyclick, repeat und bell enable
FC226A 2B7C00FC1D120DE0  move.l   #$FC1D12,$DE0(A5)   Jdostime, time vector
FC2272 203C00FC230A      move.l   #$FC230A,D0         Pointer to rts
FC2278 2B400DD8          move.l   D0,$DD8(A5)         statvec, IKBD status package
FC227C 2B400DDC          move.l   D0,$DDC(A5)         mousevec, mouse action
FC2280 2B400DE4          move.l   D0,$DE4(A5)         joyvec, joystick action
FC2284 7000              moveq.l  #0,D0               Clear sound variables
FC2286 2B400E44          move.l   D0,$E44(A5)         Sound pointer
FC228A 1B400E48          move.b   D0,$E48(A5)         Delay timer
FC228E 1B400E49          move.b   D0,$E49(A5)         Temp value
FC2292 2B400E3E          move.l   D0,$E3E(A5)         Printer timeout
FC2296 6100FC70          bsr      $FC1F08             Strobe to high
FC229A 1B7C000F0E3C      move.b   #$F,$E3C(A5)        Keyboard delay 1
FC22A0 1B7C00020E3D      move.b   #2,$E3D(A5)         Keyboard delay 2
FC22A6 41ED0DB0          lea      $DB0(A5),A0         Pointer to iorec keyboard
```

```
FC22AA 43F900FC2318         lea      $FC2318,A1           Start data for iorec
FC22B0 700D                 moveq.l #13,D0               14 bytes
FC22B2 6158                 bsr      $FC230C              Copy to RAM
FC22B4 61000C58             bsr      $FC2F0E              Pointer to BIOS keyboard table
FC22B8 13FC0003FFFFFC00     move.b   #3,$FFFFFC00         Keyboard ACIA control, master reset
FC22C0 13FC0096FFFFFC00     move.b   #$96,$FFFFFC00       /64, 8 Bit, 1 stop bit, no parity
FC22C8 267C00FC2356         move.l   #$FC2356,A3          Pointer to MFP interrupt vectors
FC22CE 7203                 moveq.l #3,D1                Initialize 4 vectors
FC22D0 2401                 move.l   D1,D2
FC22D2 2001                 move.l   D1,D0                Interrupt number
FC22D4 06000009             add.b    #9,D0                plus offset
FC22D8 E582                 asl.l    #2,D2
FC22DA 24732000             move.l   0(A3,D2.w),A2        Get vector from table
FC22DE 6100013C             bsr      $FC241C              initint, install interrupt
FC22E2 51C9FFEC             dbra     D1,$FC22D0           Next vector
FC22E6 45F900FC281C         lea      $FC281C,A2           MIDI and keyboard vector
FC22EC 7006                 moveq.l #6,D0                Vector number 6
FC22EE 6100012C             bsr      $FC241C              initint, install interrupt
FC22F2 45F900FC26B2         lea      $FC26B2,A2           CTS interrupt routine
FC22F8 7002                 moveq.l #2,D0                Vector number 2
FC22FA 61000120             bsr      $FC241C              initint, install interrupt
FC22FE 247C00FC2314         move.l   #$FC2314,A2          Pointer to init data for IKBD
FC2304 7603                 moveq.l #3,D3                4 bytes
FC2306 6100FCC0             bsr      $FC1FC8              Send string to IKBD
FC230A 4E75                 rts

FC230C 10D9                 move.b   (A1)+,(A0)+          Block move
FC230E 51C8FFFC             dbra     D0,$FC230C           Next byte
FC2312 4E75                 rts

*********************************************************
FC2314 8001121A             dc.b     $80,$01,$12,$1A      Reset Keyboard, disable mouse + joystick
```

```
*****************************************************  iorec for keyboard
FC2318 00000C0E        dc.l    $C0E                    Buffer address
FC231C 0100            dc.w    $100                    Buffer size
FC231E 0000            dc.w    0                       Head index
FC2320 0000            dc.w    0                       Tail index
FC2322 0040            dc.w    $40                     Low-water mark
FC2322 00C0            dc.w    $C0                     High-water mark

*****************************************************  iorec for MIDI
FC2326 00000D0E        dc.l    $D0E                    Buffer address
FC232A 0080            dc.w    $80                     Buffer size
FC232C 0000            dc.w    0                       Head index
FC232E 0000            dc.w    0                       Tail index
FC2330 0020            dc.w    $20                     Low-water mark
FC2332 0060            dc.w    $60                     High-water mark

*****************************************************  iorec for RS 232 input
FC2334 00000A0E        dc.l    $A0E                    Buffer address
FC2338 0100            dc.w    $100                    Buffer size
FC233A 0000            dc.w    0                       Head index
FC233C 0000            dc.w    0                       Tail index
FC233E 0040            dc.w    $40                     Low-water mark
FC2340 00C0            dc.w    $C0                     High-water mark

*****************************************************  iorec for RS 232 output
FC2342 00000B0E        dc.l    $B0E                    Buffer address
FC2346 0100            dc.w    $100                    Buffer size
FC2348 0000            dc.w    0                       Head index
FC234A 0000            dc.w    0                       Tail index
FC234C 0040            dc.w    $40                     Low-water mark
FC234E 00C0            dc.w    $C0                     High-water mark
FC2350 00              dc.b    0                       rsrbyte, receiver status
```

```
FC2351 00                dc.b    0                        tsrbyte, transmitter status
FC2352 00                dc.b    0                        rxoff
FC2353 00                dc.b    0                        txoff
FC2354 01                dc.b    1                        rsmode, XON/XOFF mode
FC2355 00                dc.b    0                        filler

*******************************************************   Interrupt vectors for MFP
FC2356 00FC2718          dc.l    $FC2718                  #9, transmitter error
FC235A 00FC2666          dc.l    $FC2666                  #10, transmitter interrupt
FC235E 00FC26FA          dc.l    $FC26FA                  #11, receiver error
FC2362 00FC2596          dc.l    $FC2596                  #12, receiver interrupt

*******************************************************   setimer, initialize timer in MFP
FC2366 48E7F8F0          movem.l D0-D4/A0-A3,-(A7)        Save registers
FC236A 207CFFFFFA01      move.l  #$FFFFFA01,A0            Address of MFP
FC2370 267C00FC23FA      move.l  #$FC23FA,A3              Timer interrupt mask bit
FC2376 247C00FC23FE      move.l  #$FC23FE,A2
FC237C 615A              bsr     $FC23D8                  mskreg
FC237E 267C00FC23EE      move.l  #$FC23EE,A3              Timer interrupt enable bit
FC2384 247C00FC23FE      move.l  #$FC23FE,A2
FC238A 614C              bsr     $FC23D8                  mskreg
FC238C 267C00FC23F2      move.l  #$FC23F2,A3              Timer interrupt pending bit
FC2392 247C00FC23FE      move.l  #$FC23FE,A2
FC2398 613E              bsr     $FC23D8                  mskreg
FC239A 267C00FC23F6      move.l  #$FC23F6,A3              Timer interrupt in-service bit
FC23A0 247C00FC23FE      move.l  #$FC23FE,A2
FC23A6 6130              bsr     $FC23D8                  mskreg
FC23A8 267C00FC2402      move.l  #$FC2402,A3              Timer control bit
FC23AE 247C00FC2406      move.l  #$FC2406,A2
FC23B4 6122              bsr     $FC23D8                  mskreg
FC23B6 C749              exg     A3,A1                    Save A3
FC23B8 47F900FC240A      lea     $FC240A,A3               Address of timer data register
```

```
FC23BE 7600         moveq.l #0,D3
FC23C0 16330000     move.b  0(A3,D0.w),D3     Get register number
FC23C4 11823000     move.b  D2,0(A0,D3.w)     Write data in MFP
FC23C8 B4303000     cmp.b   0(A0,D3.w),D2     and read
FC23CC 66F6         bne     $FC23C4           until match
FC23CE C749         exg     A3,A1             Restore A3
FC23D0 8313         or.b    D1,(A3)           Mask timer control register
FC23D2 4CDF0F1F     movem.l (A7)+,D0-D4/A0-A3 Restore registers
FC23D6 4E75         rts

*******************************************************  mskreg
FC23D8 6106         bsr     $FC23E0           getmask
FC23DA 1612         move.b  (A2),D3           Load mask
FC23DC C713         and.b   D3,(A3)           and clear bit(s)
FC23DE 4E75         rts

*******************************************************  getmask
FC23E0 7600         moveq.l #0,D3
FC23E2 D6C0         add.w   D0,A3             Base plus register number
FC23E4 1613         move.b  (A3),D3           yields address offset in MFP
FC23E6 D688         add.l   A0,D3             plus address of MFP
FC23E8 2643         move.l  D3,A3             to A3
FC23EA D4C0         add.w   D0,A2             Pointer to the mask
FC23EC 4E75         rts

*******************************************************  MFP register numbers
FC23EE 06060808     dc.b    6,6,8,8           iera, iera, ierb, ierb
FC23F2 0A0A0C0C     dc.b    10,10,12,12       ipra, ipra, iprb, iprb
FC23F6 0E0E1010     dc.b    14,14,16,16       isra, isra, isrb, isrb
FC23FA 12121414     dc.b    18,18,20,20       imra, imra, imrb, imrb
```

```
**********************************************************  Masks for MFP registers
FC23FE DFFEDFEF         dc.b    $DF,$FE,$DF,$EF     Clear bits 5, 0, 5, 0
FC2402 181A1C1C         dc.b    $18,$1A,$1C,$1C     Set bits 3+4, bits 1,3+4, bits 2-4, bits 2-4
FC2406 00008FF8         dc.b    0,0,$8F,$F8         none, none, clear bits 5-7, bits 0-2
FC240A 1E202224         dc.b    $1E,$20,$22,$24     Set bits 2-4, bits 5, bits 1+5, bits 2+5

**********************************************************  mfpint, set MFP interrupt vector
FC240E 302F0004         move.w  4(A7),D0            Interrupt number
FC2412 246F0006         move.l  6(A7),A2            Interrupt vector
FC2416 02800000000F     and.l   #15,D0              Number 0-15, long word

**********************************************************  initint, set MFP interrupt vector
FC241C 48E7E0E0         movem.l D0-D2/A0-A2,-(A7)   Save registers
FC2420 6120             bsr     $FC2442             Disable interrupts
FC2422 2400             move.l  D0,D2               Vector number
FC2424 E542             asl.w   #2,D2               As index for long word
FC2426 068200000100     add.l   #$100,D2            Plus base address of the MFP vectors
FC242C 2242             move.l  D2,A1               Vector address
FC242E 228A             move.l  A2,(A1)             Set new vector
FC2430 614A             bsr     $FC247C             Enable interrupts
FC2432 4CDF0707         movem.l (A7)+,D0-D2/A0-A2   Restore registers
FC2436 4E75             rts

**********************************************************  disint, disable MFP interrupt
FC2438 302F0004         move.w  4(A7),D0            Get interrupt number
FC243C 02800000000F     and.l   #15,D0              as long word index
FC2442 48E7C0C0         movem.l D0-D1/A0-A1,-(A7)   Save registers
FC2446 41F9FFFFFA01     lea     $FFFFFA01,A0        Address of mfp
FC244C 43E80012         lea     18(A0),A1           Address of imra
FC2450 614A             bsr     $FC249C             Calculate bit number to clear
FC2452 0391             bclr    D1,(A1)             And clear bit
FC2454 43E80006         lea     6(A0),A1            Address of iera
```

```
FC2458 6142              bsr      $FC249C             Calculate bit number to clear
FC245A 0391              bclr     D1,(A1)             And clear bit
FC245C 43E8000A          lea      10(A0),A1           Address of ipra
FC2460 613A              bsr      $FC249C             Calculate bit number to clear
FC2462 0391              bclr     D1,(A1)             And clear bit
FC2464 43E8000E          lea      14(A0),A1           Address of isra
FC2468 6132              bsr      $FC249C             Calculate bit number to clear
FC246A 0391              bclr     D1,(A1)             and clear bit
FC246C 4CDF0303          movem.l (A7)+,D0-D1/A0-A1    Restore registers
FC2470 4E75              rts

*************************************************     jenabint, enable MFP interrupt
FC2472 302F0004          move.w   4(A7),D0            Vector number
FC2476 02800000000F      and.l    #15,D0              as long word index
FC247C 48E7C0C0          movem.l D0-D1/A0-A1,-(A7)    Save registers
FC2480 41F9FFFFFA01      lea      $FFFFFA01,A0        Address of the MFP
FC2486 43E80006          lea      6(A0),A1            Address of iera
FC248A 6110              bsr      $FC249C             Calculate bit number to set
FC248C 03D1              bset     D1,(A1)             and set bit
FC248E 43E80012          lea      18(A0),A1           Address of imra
FC2492 6108              bsr      $FC249C             Calculate bit number to set
FC2494 03D1              bset     D1,(A1)             and set bit
FC2496 4CDF0303          movem.l (A7)+,D0-D1/A0-A1    Restire registers
FC249A 4E75              rts

*************************************************     bselect, determine bit and register number
FC249C 1200              move.b   D0,D1               Save interrupt number
FC249E 0C000008          cmp.b    #8,D0               Greater than 8 ?
FC24A2 6D02              blt      $FC24A6             No
FC24A4 5141              subq.w   #8,D1               Else subtract offset
FC24A6 0C000008          cmp.b    #8,D0               Greater than 8 ?
FC24AA 6C02              bge      $FC24AE             Yes
```

```
FC24AC 5449           addq.w  #2,A1        Pointer from A to B register
FC24AE 4E75           rts

******************************************************  rs232ptr
FC24B0 41F900000D8E   lea     $D8E,A0      Pointer to RS 232 iorec
FC24B6 43F9FFFFFA01   lea     $FFFFFA01,A1 Address of the MFP
FC24BC 4E75           rts

******************************************************  rs232ibuf, determine buffer contents
FC24BE 34280008       move.w  8(A0),D2     Tail index
FC24C2 36280006       move.w  6(A0),D3     Head index
FC24C6 B443           cmp.w   D3,D2        Head > tail ?
FC24C8 6204           bhi     $FC24CE      No
FC24CA D4680004       add.w   4(A0),D2     Add buffer size
FC24CE 9443           sub.w   D3,D2        Determine buffer contents
FC24D0 4E75           rts

******************************************************  rtschk
FC24D2 082800010020   btst    #1,32(A0)    RTS/CTS mode ?
FC24D8 6704           beq     $FC24DE      No
FC24DA 610008A8       bsr     $FC2D84      rtson
FC24DE 4E75           rts

******************************************************  rs232put, RS 232 output
FC24E0 40E7           move.w  SR, -(A7)    Save status
FC24E2 007C0700       or.w    #$700,SR     IPL 7, disable interrupts
FC24E6 61C8           bsr     $FC24B0      rs232ptr, get RS 232 buffer pointer
FC24E8 082800000020   btst    #0,32(A0)    XON/XOFF mode?
FC24EE 6706           beq     $FC24F6      No
FC24F0 4A28001F       tst.b   31(A0)       XON active ?
FC24F4 6618           bne     $FC250E      Yes
FC24F6 08290007002C   btst    #7,44(A1)    Is MFP still sending ?
```

```
FC24FC 6710         beq     $FC250E          Yes
FC24FE 34280014     move.w  20(A0),D2        Head index
FC2502 B4680016     cmp.w   22(A0),D2        Compare with tail index
FC2506 6606         bne     $FC250E          Characters still in buffer
FC2508 1341002E     move.b  D1,46(A1)        Byte into MFP transmitter register
FC250C 601A         bra     $FC2528
FC250E 34280016     move.w  22(A0),D2        Tail index
FC2512 610002FC     bsr     $FC2810          Test for wrap arround
FC2516 B4680014     cmp.w   20(A0),D2        Compare with head index
FC251A 6716         beq     $FC2532          Buffer full?
FC251C 2268000E     move.l  14(A0),A1        Pointer to send buffer
FC2520 13812000     move.b  D1,0(A1,D2.w)    Write byte in buffer
FC2524 31420016     move.w  D2,22(A0)        Save new tail index
FC2528 61A8         bsr     $FC24D2          rtschk, set RTS ?
FC252A 46DF         move.w  (A7)+,SR         Restore status
FC252C 023C00FE     and.b   #$FE,SR          OK, clear carry flag
FC2530 4E75         rts

FC2532 619E         bsr     $FC24D2          rtschk, set RTS?
FC2534 46DF         move.w  (A7)+,SR         Restore status
FC2536 003C0001     or.b    #1,SR            No output, set carry flag
FC253A 4E75         rts

**************************************************   rs232get, RS 232 input
FC253C 40E7         move.w  SR, -(A7)        Save status
FC253E 007C0700     or.w    #$700,SR         IPL 7, disable interrupts
FC2542 6100FF6C     bsr     $FC24B0          rs232ptr, get RS 232 pointer
FC2546 32280006     move.w  6(A0),D1         Head index
FC254A B2680008     cmp.w   8(A0),D1         Compare with tail index
FC254E 671A         beq     $FC256A          Receiver buffer empty?
FC2550 610002B2     bsr     $FC2804          Test for wrap arround
FC2554 22680000     move.l  (A0),A1          Get buffer address
```

```
FC2558 7000              moveq.l #0,D0
FC255A 10311000          move.b  0(A1,D1.w),D0     Get character from buffer
FC255E 31410006          move.w  D1,6(A0)          Save new head index
FC2562 46DF              move.w  (A7)+,SR          Restore status
FC2564 023C00FE          and.b   #$FE,SR           Character there, clear carry flag
FC2568 6006              bra     $FC2570

FC256A 46DF              move.w  (A7)+,SR          Restore status
FC256C 003C0001          or.b    #1,SR             No character, set carry flag
FC2570 082800000020      btst    #0,32(A0)         XON/XOFF mode?
FC2576 671C              beq     $FC2594           No
FC2578 4A28001E          tst.b   30(A0)            XON active ?
FC257C 6716              beq     $FC2594           No
FC257E 6100FF3E          bsr     $FC24BE           Get input buffer length
FC2582 B468000A          cmp.w   10(A0),D2         Equals low-water mark?
FC2586 660C              bne     $FC2594           No
FC2588 123C0011          move.b  #$11,D1           XON
FC258C 6100FF52          bsr     $FC24E0           Send
FC2590 4228001E          clr.b   30(A0)            Clear XON flag
FC2594 4E75              rts

******************************************************  rcvint, RS 232 receiver interrupt
FC2596 48E7F0E0          movem.l D0-D3/A0-A2,-(A7) Save registers
FC259A 6100FF14          bsr     $FC24B0           rs232ptr, get RS 232 pointer
FC259E 1169002A001C      move.b  42(A1),28(A0)     Save receiver status register
FC25A4 08280007001C      btst    #7,28(A0)         Interrupt through receiver buffer full ?
FC25AA 670000AE          beq     $FC265A           No, ignore interrupt
FC25AE 082800010020      btst    #1,32(A0)         RTS/CTS mode?
FC25B4 6704              beq     $FC25BA           No
FC25B6 610007C8          bsr     $FC2D80           rtsoff
FC25BA 1029002E          move.b  46(A1),D0         Read received byte
FC25BE 082800010020      btst    #1,32(A0)         RTS/CTS mode?
FC25C4 6640              bne     $FC2606           Yes
```

```
FC25C6 082800000020     btst    #0,32(A0)          XON/XOFF mode?
FC25CC 6738             beq     $FC2606            No
FC25CE 0C000011         cmp.b   #17,D0             XON received?
FC25D2 6624             bne     $FC25F8            No
FC25D4 117C0000001F     move.b  #0,31(A0)          Clear XOFF flag
FC25DA 34280014         move.w  20(A0),D2          Head index sender
FC25DE B4680016         cmp.w   22(A0),D2          Compare with tail index sender
FC25E2 6776             beq     $FC265A            Send buffer empty?
FC25E4 6100022A         bsr     $FC2810            Test for wrap around
FC25E8 2468000E         move.l  14(A0),A2          Pointer to send buffer
FC25EC 13722000002E     move.b  0(A2,D2.w),46(A1)  Byte in MFP transmitter register
FC25F2 31420014         move.w  D2,20(A0)          Save new head index
FC25F6 6062             bra     $FC265A
FC25F8 0C000013         cmp.b   #19,D0             XOFF received ?
FC25FC 6608             bne     $FC2606            No
FC25FE 117C00FF001F     move.b  #$FF,31(A0)        Set XOFF flag
FC2604 6054             bra     $FC265A
FC2606 32280008         move.w  8(A0),D1           Tail index
FC260A 610001F8         bsr     $FC2804            Test for wrap arround
FC260E B2680006         cmp.w   6(A0),D1           Receiver buffer full?
FC2612 6746             beq     $FC265A            Yes, ignore characters
FC2614 24680000         move.l  (A0),A2            Pointer to input buffer
FC2618 15801000         move.b  D0,0(A2,D1.w)      Received charcter in buffer
FC261C 31410008         move.w  D1,8(A0)           Save new tail index
FC2620 6100FE9C         bsr     $FC24BE            Get input buffer length used
FC2624 B468000C         cmp.w   12(A0),D2          Same as high-water mark?
FC2628 6624             bne     $FC264E            No
FC262A 082800010020     btst    #1,32(A0)          RTS/CTS mode?
FC2630 6628             bne     $FC265A            No
FC2632 082800000020     btst    #0,32(A0)          XON/XOFF mode?
FC2638 6714             beq     $FC264E            No
FC263A 4A28001E         tst.b   30(A0)             XOFF already sent?
```

```
FC263E 660E            bne      $FC264E               Yes
FC2640 117C00FF001E    move.b   #$FF,30(A0)           Flag for setting XOFF
FC2646 123C0013        move.b   #$13,D1               XOFF
FC264A 6100FE94        bsr      $FC24E0               send
FC264E 082800010020    btst     #1,32(A0)             RTS/CTS mode?
FC2654 6704            beq      $FC265A               No
FC2656 6100072C        bsr      $FC2D84               rtson
FC265A 08A90004000E    bclr     #4,14(A1)             Clear interrupt service bit
FC2660 4CDF070F        movem.l  (A7)+,D0-D3/A0-A2     Restore registers
FC2664 4E73            rte

*****************************************************  txrint, transmitter buffer empty
FC2666 48E720E0        movem.l  D2/A0-A2,-(A7)        Save registers
FC266A 6100FE44        bsr      $FC24B0               rs232ptr, get RS 232 pointer
FC266E 082800010020    btst     #1,32(A0)             RTS/CTS mode?
FC2674 6630            bne      $FC26A6               Yes, then use this interrupt
FC2676 082800000020    btst     #0,32(A0)             XON/XOFF mode?
FC267C 6706            beq      $FC2684               No
FC267E 4A28001F        tst.b    31(A0)                XOFF active ?
FC2682 6622            bne      $FC26A6               Yes, do nothing
FC2684 1169002C001D    move.b   44(A1),29(A0)         Save transmitter status register
FC268A 34280014        move.w   20(A0),D2             Head index
FC268E B4680016        cmp.w    22(A0),D2             Compare with tail index
FC2692 6712            beq      $FC26A6               Send buffer empty?
FC2694 6100017A        bsr      $FC2810               Test for wrap around
FC2698 2468000E        move.l   14(A0),A2             Pointer to send buffer
FC269C 13722000002E    move.b   0(A2,D2.w),46(A1)     Byte in MFP transmitter register
FC26A2 31420014        move.w   D2,20(A0)             Save new head index
FC26A6 08A90002000E    bclr     #2,14(A1)             Clear interrupt service bit
FC26AC 4CDF0704        movem.l  (A7)+,D2/A0-A2        Restore registers
FC26B0 4E73            rte
```

```
******************************************************  ctsint, CTS interrupt routine
FC26B2 48E720E0          movem.l D2/A0-A2,-(A7)      Save registers
FC26B6 6100FDF8          bsr     $FC24B0             rs232ptr, get RS 232 pointer
FC26BA 082800010020      btst    #1,32(A0)           RTS/CTS mode?
FC26C0 672A              beq     $FC26EC             No, ignore interrupt
FC26C2 1169002C001D      move.b  44(A1),29(A0)       Save transmitter status
FC26C8 08280007001D      btst    #7,29(A0)           Transmitter buffer empty ?
FC26CE 67F8              beq     $FC26C8             No, wait (must jump to $FC26C2!)
FC26D0 34280014          move.w  20(A0),D2           Head index
FC26D4 B4680016          cmp.w   22(A0),D2           Compare with tail index
FC26D8 671E              beq     $FC26F8             Send buffer empty
FC26DA 61000134          bsr     $FC2810             Test for wrap around
FC26DE 2468000E          move.l  14(A0),A2           Pointer to send buffer
FC26E2 13722000002E      move.b  0(A2,D2.w),46(A1)   Byte in MFP transmitter register
FC26E8 31420014          move.w  D2,20(A0)           Save new head index
FC26EC 08A900020010      bclr    #2,16(A1)           Clear interrupt service bit
FC26F2 4CDF0704          movem.l (A7)+,D2/A0-A2      Restore registers
FC26F6 4E73              rte

FC26F8 60F2              bra     $FC26EC             Send buffer empty
******************************************************  rxerror, RS 232 receiver error
FC26FA 48E780C0          movem.l D0/A0-A1,-(A7)      Save registers
FC26FE 6100FDB0          bsr     $FC24B0             rs232ptr, get RS 232 pointer
FC2702 1169002A001C      move.b  42(A1),28(A0)       Save receiver status
FC2708 1029002E          move.b  46(A1),D0           Read data register (clear status)
FC270C 08A90003000E      bclr    #3,14(A1)           Clear interrupt service bit
FC2712 4CDF0301          movem.l (A7)+,D0/A0-A1      Restore registers
FC2716 4E73              rte

******************************************************  txerror, RS 232 send error
FC2718 48E700C0          movem.l A0-A1,-(A7)         Save registers
FC271C 6100FD92          bsr     $FC24B0             rs232ptr, get RS 232 pointer
```

```
FC2720 1169002C001D        move.b   44(A1),29(A0)      Save transmitter status
FC2726 08A90001000E        bclr     #1,14(A1)          Clear interrupt service bit
FC272C 4CDF0300            movem.l  (A7)+/A0-A1        Restore registers
FC2730 4E73                rte

*******************************************************  get iorec
FC2732 7200                moveq.l  #0,D1
FC2734 322F0004            move.w   4(A7),D1           Device number
FC2738 40E7                move.w   SR, -(A7)          Save status
FC273A 007C0700            or.w     #$700,SR           IPL 7, disable interrupts
FC273E 45F900FC274E        lea      $FC274E,A2         Address of the table
FC2744 E581                asl.l    #2,D1              Long access
FC2746 20321800            move.l   0(A2,D1.l),D0      Get pointer to iorec
FC274A 46DF                move.w   (A7)+,SR           Restore status
FC274C 4E75                rts

*******************************************************  iorec table
FC274E 00000D8E            dc.l     $D8E               RS 232
FC2752 00000DB0            dc.l     $DB0               IKBD
FC2756 00000DBE            dc.l     $DBE               MIDI

*******************************************************  rsconf, configure RS 232
FC275A 007C0700            or.w     #$700,SR           IPL 7, disable interrupts
FC275E 6100FD50            bsr      $FC24B0            rs232ptr, get RS 232 pointer
FC2762 0F490028            movep.l  $28(A1),D7         Save ucr, rsr, tsr and scr
FC2766 4A6F0006            tst.w    6(A7)              Mode
FC276A 6B0A                bmi      $FC2776            Negative, don't reset
FC276C 116F00070020        move.b   7(A7),32(A0)       Reset rsmode
FC2772 7000                moveq.l  #0,D0
FC2774 7400                moveq.l  #0,D2
FC2776 4A6F0004            tst.w    4(A7)              Baud rate
FC277A 6B34                bmi      $FC27B0            Negative, don't change
```

```
FC277C 7000                  moveq.l #0,D0
FC277E 1340002A              move.b  D0,42(A1)          Disable receiver
FC2782 1340002C              move.b  D0,44(A1)          Disable sender
FC2786 322F0004              move.w  4(A7),D1           Get new baud rate
FC278A 45F900FC27E4          lea     $FC27E4,A2         Table of timer values, control registers
FC2790 10321000              move.b  0(A2,D1.w),D0      Get value
FC2794 45F900FC27F4          lea     $FC27F4,A2         Table of timer values, data registers
FC279A 14321000              move.b  0(A2,D1.w),D2      Get value
FC279E 2200                  move.l  D0,D1
FC27A0 7003                  moveq.l #3,D0              Pointer to timer D
FC27A2 6100FBC2              bsr     $FC2366            Set timer D for new baud rate
FC27A6 7001                  moveq.l #1,D0
FC27A8 1340002A              move.b  D0,42(A1)          Enable receiver
FC27AC 1340002C              move.b  D0,44(A1)          Enable sender
FC27B0 4A6F0008              tst.w   8(A7)              Set ucr ?
FC27B4 6B06                  bmi     $FC27BC            No
FC27B6 136F00090028          move.b  9(A7),40(A1)       New ucr value
FC27BC 4A6F000A              tst.w   10(A7)             Set rsr ?
FC27C0 6B06                  bmi     $FC27C8            No
FC27C2 136F000B002A          move.b  11(A7),42(A1)      New rsr value
FC27C8 4A6F000C              tst.w   12(A7)             Set tsr?
FC27CC 6B06                  bmi     $FC27D4            No
FC27CE 136F000D002C          move.b  13(A7),44(A1)      New tsr value
FC27D4 4A6F000E              tst.w   14(A7)             Set scr?
FC27D8 6B06                  bmi     $FC27E0            No
FC27DA 136F000F0026          move.b  15(A7),38(A1)      Set scr
FC27E0 2007                  move.l  D7,D0              old value for control register
FC27E2 4E75                  rts

*************************************************       Timer values for RS 232 baud rate
FC27E4 0101010101010101      dc.b    1,1,1,1,1,1,1,1    Control register
FC27EC 0101010101010202      dc.b    1,1,1,1,1,1,2,2    1 = /4, 2 = /10
```

```
FC27F4 01020405080A0B10      dc.b     1,2,4,5,8,10,11,16       Data register
FC27FC 204060808FAFF4060     dc.b     32,64,96,128,143,175,64,96

****************************************************** wrapin, test for wrap around
FC2804 5241                  addq.w   #1,D1                    Head index + 1
FC2806 B2680004              cmp.w    4(A0),D1                 Equals buffer size?
FC280A 6502                  bcs      $FC280E                  No
FC280C 7200                  moveq.l  #0,D1                    Else begin with zero
FC280E 4E75                  rts

****************************************************** wrapout, test for wrap around
FC2810 5242                  addq.w   #1,D2                    Tail index + 1
FC2812 B4680012              cmp.w    18(A0),D2                Equals buffer size?
FC2816 6502                  bcs      $FC281A                  No
FC2818 7400                  moveq.l  #0,D2                    Else begin with zero
FC281A 4E75                  rts

****************************************************** midikey, keyboard and MIDI interrupt
FC281C 48E7F0F4              movem.l  D0-D3/A0-A3/A5,-(A7)     Save registers
FC2820 4BF900000000          lea      $0,A5                    Clear A5
FC2826 246D0DE8              move.l   $DE8(A5),A2              mbufrec, MIDI
FC282A 4E92                  jsr      (A2)                     Interrupt from MIDI ACIA ?
FC282C 246D0DEC              move.l   $DEC(A5),A2              kbufrec, keyboard
FC2830 4E92                  jsr      (A2)                     Interrupt from keyboard ACIA ?
FC2832 08390004FFFFFA01      btst     #4,$FFFFFA01             mfp gpip, still an interrupt there?
FC283A 67EA                  beq      $FC2826                  Yes, proces
FC283C 08B90006FFFFFA11      bclr     #6,$FFFFFA11             Clear interrupt service bit
FC2844 4CDF2F0F              movem.l  (A7)+,D0-D3/A0-A3/A5     Restore registers
FC2848 4E73                  rte

****************************************************** midisys, MIDI interrupt
FC284A 41ED0DBE              lea      $DBE(A5),A0              iorec for MIDI
```

```
FC284E 43F9FFFFFC04       lea      $FFFFFC04,A1       MIDI ACIA control
FC2854 246D0DD4           move.l   $DD4(A5),A2        MIDI error routine
FC2858 600E               bra      $FC2868

*****************************************************  ikbdsys, keyboard interrupt
FC285A 41ED0DB0           lea      $DB0(A5),A0        iorec for keyboard
FC285E 43F9FFFFFC00       lea      $FFFFFC00,A1       Keyboard ACIA control
FC2864 246D0DD0           move.l   $DD0(A5),A2        Keyboard error routine
FC2868 14290000           move.b   (A1),D2            Get ACIA status
FC286C 08020007           btst     #7,D2              Interrupt request ?
FC2870 671C               beq      $FC288E            No
FC2872 08020000           btst     #0,D2              Receiver buffer full?
FC2876 670A               beq      $FC2882            No
FC2878 48E720E0           movem.l  D2/A0-A2,-(A7)     Save registers
FC287C 6112               bsr      $FC2890            arcvint, get byte
FC287E 4CDF0704           movem.l  (A7)+,D2/A0-A2     Restore registers
FC2882 02020020           and.b    #$20,D2            Clear tested bit
FC2886 6706               beq      $FC288E            No error
FC2888 10290002           move.b   2(A1),D0           Read data again, clear status
FC288C 4ED2               jmp      (A2)               Execute error routine
FC288E 4E75               rts

*****************************************************  arcvint, get byte from ACIA
FC2890 10290002           move.b   2(A1),D0           get data from ACIA
FC2894 B1FC00000DB0       cmp.l    #$DB0,A0           Keyboard ACIA ?
FC289A 66000440           bne      $FC2CDC            No, MIDI
FC289E 4A2D0DF0           tst.b    $DF0(A5)           Keyboard state
FC28A2 6660               bne      $FC2904
FC28A4 0C0000F6           cmp.b    #$F6,D0            Keypress ?
FC28A8 65000100           bcs      $FC29AA            yes
FC28AC 040000F6           sub.b    #$F6,D0            Subtract offset
FC28B0 0280000000FF       and.l    #$FF,D0
```

```
FC28B6 47F900FC28F0         lea      $FC28F0,A3         Pointer to IKBD code table
FC28BC 1B7300000DF0         move.b   0(A3,D0.w),$DF0(A5)  Save IKBD
FC28C2 47F900FC28FA         lea      $FC28FA,A3         Pointer to IKBD length table
FC28C8 1B7300000DF1         move.b   0(A3,D0.w),$DF1(A5)  IKBD index
FC28CE 064000F6             add.w    #$F6,D0            Add offset again
FC28D2 0C0000F8             cmp.b    #$F8,D0            Mouse position record ?
FC28D6 6D0C                 blt      $FC28E4            No
FC28D8 0C0000FB             cmp.b    #$FB,D0            Mouse position record ?
FC28DC 6E06                 bgt      $FC28E4            No
FC28DE 1B400DFE             move.b   D0,$DFE(A5)        Save mouse position
FC28E2 4E75                 rts
FC28E4 0C0000FD             cmp.b    #$FD,D0            Joystick record ?
FC28E8 6D04                 blt      $FC28EE            No
FC28EA 1B400E07             move.b   D0,$E07(A5)        Save joystick data
FC28EE 4E75                 rts

*************************************************** IKBD parameters
FC28F0 01020303030304050607 dc.b     1,2,3,3,3,3,4,5,6,7  Status code for $F6-$FF
FC28FA 07050202020206020101 dc.b     7,5,2,2,2,2,6,2,1,1  Length-1 for $F6-$FF

****************************************************
FC2904 0C2D00060DF0         cmp.b    #6,$DF0(A5)        Joystick record ?
FC290A 64000084             bcc      $FC2990            Yes
FC290E 45F900FC2954         lea      $FC2954,A2         Pointer to IKBD parameter table
FC2914 7400                 moveq.l  #0,D2
FC2916 142D0DF0             move.b   $DF0(A5),D2        Kstate
FC291A 5302                 subq.b   #1,D2              1-5 => 0-4
FC291C E342                 asl.w    #1,D2              times 2
FC291E D42D0DF0             add.b    $DF0(A5),D2        plus once
FC2922 5302                 subq.b   #1,D2
FC2924 E542                 asl.w    #2,D2
FC2926 20722000             move.l   0(A2,D2.w),A0      IKBD record pointer
```

```
FC292A 22722004         move.l  4(A2,D2.w),A1        IKBD index base
FC292E 24722008         move.l  8(A2,D2.w),A2        IKBD interrupt routine
FC2932 2452             move.l  (A2),A2              Get interrupt vector
FC2934 7400             moveq.l #0,D2
FC2936 142D0DF1         move.b  $DF1(A5),D2          Get IKBD index
FC293A 93C2             sub.l   D2,A1                minus base
FC293C 1280             move.b  D0,(A1)
FC293E 532D0DF1         subq.b  #1,$DF1(A5)          IKBD index minus 1
FC2942 4A2D0DF1         tst.b   $DF1(A5)             Test index
FC2946 660A             bne     $FC2952
FC2948 2F08             move.l  A0,-(A7)             Pass record pointer
FC294A 4E92             jsr     (A2)                 Execute interrupt routine
FC294C 584F             addq.w  #4,A7                Correct stack pointer
FC294E 422D0DF0         clr.b   $DF0(A5)             Clear IKBD state
FC2952 4E75             rts

*****************************************************  Parameter table for IKBD
FC2954 00000DF2         dc.l    $DF2
FC2958 00000DF9         dc.l    $DF9
FC295C 00000DD8         dc.l    $DD8
FC2960 00000DF9         dc.l    $DF9
FC2964 00000DFE         dc.l    $DFE
FC2968 00000DDC         dc.l    $DDC
FC296C 00000DFE         dc.l    $DFE
FC2970 00000E01         dc.l    $E01
FC2974 00000DDC         dc.l    $DDC
FC2978 00000E01         dc.l    $E01
FC297C 00000E07         dc.l    $E07
FC2980 00000DE0         dc.l    $DE0
FC2984 00000E07         dc.l    $E07
FC2988 00000E09         dc.l    $E09
FC298C 00000DE4         dc.l    $DE4
```

```
**********************************************
FC2990 223C00000E08     move.l  #$E08,D1
FC2996 D22D0DF0         add.b   $DF0(A5),D1       Joystick 0 and 1
FC299A 5D01             subq.b  #6,D1
FC299C 2441             move.l  D1,A2
FC299E 1480             move.b  D0,(A2)
FC29A0 246D0DE4         move.l  $DE4(A5),A2       Joystick interrupt routine
FC29A4 41ED0E07         lea     $E07(A5),A0       Address of joystick data
FC29A8 609E             bra     $FC2948

*******************************************************  Process keypress
FC29AA 122D0E1B         move.b  $E1B(A5),D1       Shift status
FC29AE 0C00002A         cmp.b   #$2A,D0           Left shift key pressed?
FC29B2 6606             bne     $FC29BA           No
FC29B4 08C10001         bset    #1,D1             Set bit for left shift key
FC29B8 6074             bra     $FC2A2E
FC29BA 0C0000AA         cmp.b   #$AA,D0           Left shift key released?
FC29BE 6606             bne     $FC29C6           No
FC29C0 08810001         bclr    #1,D1             Clear bit for left shift key
FC29C4 6068             bra     $FC2A2E
FC29C6 0C000036         cmp.b   #$36,D0           Right shift key pressed?
FC29CA 6606             bne     $FC29D2           No
FC29CC 08C10000         bset    #0,D1             Set bit for right shift key
FC29D0 605C             bra     $FC2A2E
FC29D2 0C0000B6         cmp.b   #$B6,D0           Right shift key released?
FC29D6 6606             bne     $FC29DE           No
FC29D8 08810000         bclr    #0,D1             Clear bit for right shift key
FC29DC 6050             bra     $FC2A2E
FC29DE 0C00001D         cmp.b   #$1D,D0           CTRL key pressed?
FC29E2 6606             bne     $FC29EA           No
FC29E4 08C10002         bset    #2,D1             Set bit for CTRL key
FC29E8 6044             bra     $FC2A2E
```

```
FC29EA 0C00009D          cmp.b   #$9D,D0             CTRL key released?
FC29EE 6606              bne     $FC29F6             No
FC29F0 08810002          bclr    #2,D1               Clear bit for CTRL key
FC29F4 6038              bra     $FC2A2E
FC29F6 0C000038          cmp.b   #$38,D0             ALT key pressed?
FC29FA 6606              bne     $FC2A02             No
FC29FC 08C10003          bset    #3,D1               Set bit for ALT key
FC2A00 602C              bra     $FC2A2E
FC2A02 0C0000B8          cmp.b   #$B8,D0             ALT key released?
FC2A06 6606              bne     $FC2A0E             No
FC2A08 08810003          bclr    #3,D1               Clear bit for ALT key
FC2A0C 6020              bra     $FC2A2E
FC2A0E 0C00003A          cmp.b   #$3A,D0             CAPS LOCK pressed ?
FC2A12 6620              bne     $FC2A34             No
FC2A14 082D00000484      btst    #0,$484(A5)         conterm, key click ?
FC2A1A 670E              beq     $FC2A2A             No
FC2A1C 2B7C00FC30940E44  move.l  #$FC3094,$E44(A5)   Addres of key click sound table
FC2A24 1B7C00000E48      move.b  #0,$E48(A5)         Start sound
FC2A2A 08410004          bchg    #4,D1               Invert CAPS LOCK status
FC2A2E 1B410E1B          move.b  D1,$E1B(A5)         Save new shift status
FC2A32 4E75              rts

FC2A34 08000007          btst    #7,D0               Was key released?
FC2A38 662A              bne     $FC2A64             Yes
FC2A3A 4A2D0E39          tst.b   $E39(A5)            Repeat ?
FC2A3E 6616              bne     $FC2A56             Yes
FC2A40 1B400E39          move.b  D0,$E39(A5)         Save key code for repeat
FC2A44 1B7900000E3C0E3A  move.b  $E3C,$E3A(A5)       Delay 1
FC2A4C 1B7900000E3D0E3B  move.b  $E3D,$E3B(A5)       Delay 2
FC2A54 603A              bra     $FC2A90
```

```
FC2A56 1B7C00000E3A       move.b  #0,$E3A(A5)        Clear counter for delay 1
FC2A5C 1B7C00000E3B       move.b  #0,$E3B(A5)        Clear counter for delay 2
FC2A62 602C               bra     $FC2A90
FC2A64 4A2D0E39           tst.b   $E39(A5)           Key for repeat?
FC2A68 670E               beq     $FC2A78            No
FC2A6A 7200               moveq.l #0,D1
FC2A6C 1B410E39           move.b  D1,$E39(A5)        Clear key code for repeat
FC2A70 1B410E3A           move.b  D1,$E3A(A5)        Clear delay 1
FC2A74 1B410E3B           move.b  D1,$E3B(A5)        Clear delay 2
FC2A78 0C0000C7           cmp.b   #$C7,D0            HOME key released?
FC2A7C 6708               beq     $FC2A86            Yes
FC2A7E 0C0000D2           cmp.b   #$D2,D0            INSERT key released?
FC2A82 66000256           bne     $FC2CDA            No
FC2A86 082D00030E1B       btst    #3,$E1B(A5)        ALT key still pressed?
FC2A8C 6700024C           beq     $FC2CDA            No
FC2A90 082D00000484       btst    #0,$484(A5)        conterm, key click ?
FC2A96 670E               beq     $FC2AA6            No
FC2A98 2B7C00FC30940E44   move.l  #$FC3094,$E44(A5)  Address of sound table for key click
FC2AA0 1B7C00000E48       move.b  #0,$E48(A5)        Start sound
FC2AA6 2F08               move.l  A0,-(A7)           Save iorec for keyboard
FC2AA8 7200               moveq.l #0,D1
FC2AAA 1200               move.b  D0,D1              Scancode to D1
FC2AAC 206D0E1C           move.l  $E1C(A5),A0        Address of the standard keyboard table
FC2AB0 0240007F           and.w   #$7F,D0            Clear bit for released
FC2AB4 082D00040E1B       btst    #4,$E1B(A5)        CAPS LOCK active ?
FC2ABA 6704               beq     $FC2AC0            No
FC2ABC 206D0E24           move.l  $E24(A5),A0        Address of CAPS LOCK keyboard table
FC2AC0 082D00000E1B       btst    #0,$E1B(A5)        Right shift key pressed?
FC2AC6 6608               bne     $FC2AD0            Yes
FC2AC8 082D00010E1B       btst    #1,$E1B(A5)        Left shift key pressed?
FC2ACE 671A               beq     $FC2AEA            No
FC2AD0 0C00003B           cmp.b   #$3B,D0            Function key ? (F1)
```

```
FC2AD4 6510          bcs     $FC2AE6          No
FC2AD6 0C000044      cmp.b   #$44,D0          Function key ? (F10)
FC2ADA 620A          bhi     $FC2AE6          No
FC2ADC 06410019      add.w   #$19,D1          Add offset to GSX standard
FC2AE0 7000          moveq.l #0,D0            ASCII code equals zero
FC2AE2 600001B2      bra     $FC2C96
FC2AE6 206D0E20      move.l  $E20(A5),A0      Address of the shift keyboard table
FC2AEA 10300000      move.b  0(A0,D0.w),D0    Get ASCII code from table
FC2AEE 082D00020E1B  btst    #2,$E1B(A5)      CTRL key table?
FC2AF4 6760          beq     $FC2B56          No
FC2AF6 0C00000D      cmp.b   #13,D0           Carriage return?
FC2AFA 6604          bne     $FC2B00          No
FC2AFC 700A          moveq.l #10,D0           Convert to linefeed
FC2AFE 672A          beq     $FC2B2A
FC2B00 0C010047      cmp.b   #$47,D1          CTRL HOME?
FC2B04 6608          bne     $FC2B0E          No
FC2B06 06410030      add.w   #$30,D1          Add offset to GSX standard
FC2B0A 6000018A      bra     $FC2C96
FC2B0E 0C01004B      cmp.b   #$4B,D1          CTRL cursor left?
FC2B12 6608          bne     $FC2B1C          No
FC2B14 7273          moveq.l #$73,D1          GSX standard
FC2B16 7000          moveq.l #0,D0            ASCII code zero
FC2B18 6000017C      bra     $FC2C96
FC2B1C 0C01004D      cmp.b   #$4D,D1          CTRL cursor right ?
FC2B20 6608          bne     $FC2B2A          No
FC2B22 7274          moveq.l #$74,D1          GSX standard
FC2B24 7000          moveq.l #0,D0            ASCII code zero
FC2B26 6000016E      bra     $FC2C96
FC2B2A 0C000032      cmp.b   #$32,D0          CTRL M ?
FC2B2E 6606          bne     $FC2B36
FC2B30 7000          moveq.l #0,D0            ASCII code zero
FC2B32 60000162      bra     $FC2C96
```

```
FC2B36 0C000036        cmp.b     #$36,D0          CTRL Shift ?
FC2B3A 6606            bne       $FC2B42
FC2B3C 701E            moveq.l   #$1E,D0          ASCI code RS
FC2B3E 60000156        bra       $FC2C96
FC2B42 0C00002D        cmp.b     #$2D,D0          CTRL C ?
FC2B46 6606            bne       $FC2B4E
FC2B48 701F            moveq.l   #$1F,D0          ASCII code US
FC2B4A 6000014A        bra       $FC2C96
FC2B4E 0240001F        and.w     #$1F,D0          Convert code to CTRL code
FC2B52 60000142        bra       $FC2C96
FC2B56 082D00030E1B    btst      #3,$E1B(A5)      ALT key pressed?
FC2B5C 67000138        beq       $FC2C96          No
FC2B60 0C01001A        cmp.b     #26,D1           Key 'Ü' ?
FC2B64 6618            bne       $FC2B7E          No
FC2B66 103C0040        move.b    #$40,D0          '@'
FC2B6A 142D0E1B        move.b    $E1B(A5),D2      Shift status
FC2B6E 02020003        and.b     #3,D2            One of the shift keys pressed?
FC2B72 67000122        beq       $FC2C96          No
FC2B76 103C005C        move.b    #$5C,D0          '\'
FC2B7A 6000011A        bra       $FC2C96
FC2B7E 0C010027        cmp.b     #39,D1           Key 'Ö' ?
FC2B82 6618            bne       $FC2B9C
FC2B84 103C005B        move.b    #$5B,D0          '['
FC2B88 142D0E1B        move.b    $E1B(A5),D2      Shift status
FC2B8C 02020003        and.b     #3,D2            One of the shift keys pressed?
FC2B90 67000104        beq       $FC2C96          No
FC2B94 103C007B        move.b    #$7B,D0          '{'
FC2B98 600000FC        bra       $FC2C96
FC2B9C 0C010028        cmp.b     #40,D1           Key 'Ä' ?
FC2BA0 6618            bne       $FC2BBA          No
FC2BA2 103C005D        move.b    #$5D,D0          ']'
FC2BA6 142D0E1B        move.b    $E1B(A5),D2      Shift status
```

```
FC2BAA 02020003       and.b    #3,D2            One of the shift keys pressed?
FC2BAE 670000E6       beq      $FC2C96          No
FC2BB2 103C007D       move.b   #$7D,D0          '}'
FC2BB6 600000DE       bra      $FC2C96
FC2BBA 0C010062       cmp.b    #98,D1           ALT HELP ?
FC2BBE 660A           bne      $FC2BCA          No
FC2BC0 526D04EE       addq.w   #1,$4EE(A5)      _dumpflg for hardcopy
FC2BC4 205F           move.l   (A7)+,A0         Restore keyboard iorec
FC2BC6 60000112       bra      $FC2CDA

FC2BCA 45F900FC2D48   lea      $FC2D48,A2       Pointer to mouse scancode table
FC2BD0 7403           moveq.l  #3,D2            Test four values
FC2BD2 B2322000       cmp.b    0(A2,D2.w),D1    Value found?
FC2BD6 6700012C       beq      $FC2D04          Yes
FC2BDA 51CAFFF6       dbra     D2,$FC2BD2       Next value
FC2BDE 0C010048       cmp.b    #$48,D1          Cursor up?
FC2BE2 661C           bne      $FC2C00          No
FC2BE4 123C0000       move.b   #0,D1            X-offset for cursor up
FC2BE8 143CFFF8       move.b   #-8,D2           Y-offset for cursor up
FC2BEC 102D0E1B       move.b   $E1B(A5),D0      Get shift status
FC2BF0 02000003       and.b    #3,D0            One of the shift keys pressed?
FC2BF4 6700012C       beq      $FC2D22          No
FC2BF8 143CFFFF       move.b   #-1,D2           Y-offset, only one pixel high
FC2BFC 60000124       bra      $FC2D22
FC2C00 0C01004B       cmp.b    #$4B,D1          Cursor left ?
FC2C04 661C           bne      $FC2C22          No
FC2C06 143C0000       move.b   #0,D2            Y-offset for cursor left
FC2C0A 123CFFF8       move.b   #-8,D1           X-offset for cursor left
FC2C0E 102D0E1B       move.b   $E1B(A5),D0      Get shift status
FC2C12 02000003       and.b    #3,D0            One of the shift keys pressed?
FC2C16 6700010A       beq      $FC2D22          No
FC2C1A 123CFFFF       move.b   #-1,D1           X-offset, only one pixel left
```

```
FC2C1E 60000102    bra      $FC2D22
FC2C22 0C01004D    cmp.b    #$4D,D1        Cursor right ?
FC2C26 661C        bne      $FC2C44        No
FC2C28 123C0008    move.b   #8,D1          X-offset for cursor right
FC2C2C 143C0000    move.b   #0,D2          Y-offset for cursor right
FC2C30 102D0E1B    move.b   $E1B(A5),D0    Get shift status
FC2C34 02000003    and.b    #3,D0          One of the shift keys pressed?
FC2C38 670000E8    beq      $FC2D22        No
FC2C3C 123C0001    move.b   #1,D1          X-offset, only one pixel right
FC2C40 600000E0    bra      $FC2D22
FC2C44 0C010050    cmp.b    #$50,D1        Cursor down ?
FC2C48 661C        bne      $FC2C66        No
FC2C4A 123C0000    move.b   #0,D1          X-offset for cursor down
FC2C4E 143C0008    move.b   #8,D2          Y-offset for cursor down
FC2C52 102D0E1B    move.b   $E1B(A5),D0    Shift status
FC2C56 02000003    and.b    #3,D0          One of the shift keys pressed?
FC2C5A 670000C6    beq      $FC2D22        No
FC2C5E 143C0001    move.b   #1,D2          Y-offset, only one pixel down
FC2C62 600000BE    bra      $FC2D22
FC2C66 0C010002    cmp.b    #2,D1          '1'
FC2C6A 650C        bcs      $FC2C78
FC2C6C 0C01000D    cmp.b    #13,D1         '='
FC2C70 6206        bhi      $FC2C78
FC2C72 06010076    add.b    #118,D1
FC2C76 600C        bra      $FC2C84
FC2C78 0C000041    cmp.b    #65,D0         'A'
FC2C7C 650A        bcs      $FC2C88
FC2C7E 0C00005A    cmp.b    #90,D0         'Z'
FC2C82 6204        bhi      $FC2C88
FC2C84 7000        moveq.l  #0,D0
FC2C86 600E        bra      $FC2C96
FC2C88 0C000061    cmp.b    #97,D0         'a'
```

```
FC2C8C 6508                bcs      $FC2C96
FC2C8E 0C00007A            cmp.b    #122,D0          'z'
FC2C92 6202                bhi      $FC2C96
FC2C94 60EE                bra      $FC2C84
FC2C96 E141                asl.w    #8,D1            Scancode to bits 8-15
FC2C98 D041                add.w    D1,D0            plus ASCII code
FC2C9A 205F                move.l   (A7)+,A0         iorec pointer to keyboard
FC2C9C 32280008            move.w   8(A0),D1         Tail index
FC2CA0 5841                addq.w   #4,D1            plus 4
FC2CA2 B2680004            cmp.w    4(A0),D1         End of buffer reached?
FC2CA6 6502                bcs      $FC2CAA          No
FC2CA8 7200                moveq.l  #0,D1            Start over again
FC2CAA B2680006            cmp.w    6(A0),D1         Buffer full?
FC2CAE 672A                beq      $FC2CDA          Yes, ignore data
FC2CB0 24680000            move.l   (A0),A2          Address of the buffer
FC2CB4 4840                swap     D0               ASCII code to bits 16-23
FC2CB6 303C0000            move.w   #0,D0
FC2CBA 102D0E1B            move.b   $E1B(A5),D0      Shift status
FC2CBE 4840                swap     D0               in upper word
FC2CC0 E188                lsl.l    #8,D0            in bits 24-31
FC2CC2 E048                lsr.w    #8,D0            ASCII code to bits 0-7
FC2CC4 082D00030484        btst     #3,$484(A5)      conterm, accept shift status?
FC2CCA 6606                bne      $FC2CD2          Yes
FC2CCC 028000FFFFFF        and.l    #$00FFFFFF,D0    Clear shift status
FC2CD2 25801000            move.l   D0,0(A2,D1.w)    Write data in keyboard buffer
FC2CD6 31410008            move.w   D1,8(A0)         Update buffer pointer
FC2CDA 4E75                rts

*************************************************    midibyte
FC2CDC 246D0DCC            move.l   $DCC(A5),A2      Pointer to MIDI interrupt handler
FC2CE0 4ED2                jmp      (A2)             Execute routine
```

```
*****************************************************  sysmidi
FC2CE2 32280008         move.w  8(A0),D1         Tail index
FC2CE6 5241             addq.w  #1,D1            Increment
FC2CE8 B2680004         cmp.w   4(A0),D1         End of buffer reached?
FC2CEC 6502             bcs     $FC2CF0          No
FC2CEE 7200             moveq.l #0,D1            Buffer pointer back to buffer start
FC2CF0 B2680006         cmp.w   6(A0),D1         Head equals tail ?
FC2CF4 670C             beq     $FC2D02          Yes, buffer full
FC2CF6 24680000         move.l  (A0),A2          Buffer address
FC2CFA 15801000         move.b  D0,0(A2,D1.w)    Write byte in buffer
FC2CFE 31410008         move.w  D1,8(A0)         New tail index
FC2D02 4E75             rts

*****************************************************  keymaus1
FC2D04 7605             moveq.l #5,D3            Accept right button
FC2D06 08010004         btst    #4,D1
FC2D0A 6702             beq     $FC2D0E          is right button ($47/$C7)
FC2D0C 7606             moveq.l #6,D3            Left button
FC2D0E 08010007         btst    #7,D1            Pressed or released?
FC2D12 6706             beq     $FC2D1A          pressed
FC2D14 07AD0E1B         bclr    D3,$E1B(A5)      Clear bit for button
FC2D18 6004             bra     $FC2D1E
FC2D1A 07ED0E1B         bset    D3,$E1B(A5)      Set bit for button
FC2D1E 7200             moveq.l #0,D1            X to 0
FC2D20 7400             moveq.l #0,D2            Y to 0

*****************************************************  keymouse
FC2D22 41ED0E18         lea     $E18(A5),A0      Pointer to mouse emulator buffer
FC2D26 246D0DDC         move.l  $DDC(A5),A2      Mouse interrupt vector
FC2D2A 4280             clr.l   D0
FC2D2C 102D0E1B         move.b  $E1B(A5),D0      Get status of the "mouse" buttons
FC2D30 EA08             lsr.b   #5,D0            Bit for right/left to bits 0/1
```

```
FC2D32 060000F8       add.b    #$F8,D0           plus relative mouse header
FC2D36 11400000       move.b   D0,(A0)           in buffer
FC2D3A 11410001       move.b   D1,1(A0)          Store X-value
FC2D3E 11420002       move.b   D2,2(A0)          Store Y-value
FC2D42 4E92           jsr      (A2)              Call mouse interrupt routine
FC2D44 205F           move.l   (A7)+,A0          iorec for keyboard back
FC2D46 4E75           rts

*****************************************************  mousekey1
FC2D48 47C752D2       dc.b     $47,$C7,$52,$D2   Scancode for pseudo mouse

*****************************************************  giaccess,read write sound chip
FC2D4C 302F0004       move.w   4(A7),D0          Data
FC2D50 322F0006       move.w   6(A7),D1          Register number plus read/write
FC2D54 40E7           move.w   SR, -(A7)         Save status
FC2D56 007C0700       or.w     #$700,SR          IPL 7, disable interrupts
FC2D5A 48E76080       movem.l  D1-D2/A0,-(A7)    Save registers
FC2D5E 41F9FFFF8800   lea      $FFFF8800,A0      Address of the sound chip
FC2D64 1401           move.b   D1,D2             Get register number
FC2D66 0201000F       and.b    #$F,D1            Registers 0-15
FC2D6A 1081           move.b   D1,(A0)           Select register
FC2D6C E302           asl.b    #1,D2             Test read/write bit
FC2D6E 6404           bcc      $FC2D74           Read
FC2D70 11400002       move.b   D0,2(A0)          Write data byte in sound chip register
FC2D74 7000           moveq.l  #0,D0
FC2D76 1010           move.b   (A0),D0           Read byte from sound chip
FC2D78 4CDF0106       movem.l  (A7)+,D1-D2/A0    Restore registers
FC2D7C 46DF           move.w   (A7)+,SR          Restore status
FC2D7E 4E75           rts
```

```
*******************************************************     rtsoff, turn RTS off
FC2D80 7408              moveq.l #8,D2                 Bit 3
FC2D82 6012              bra     $FC2D96               Set in port A

*******************************************************     rtson, turn RTS on
FC2D84 74F7              moveq.l #$F7,D2               Bit 3
FC2D86 6034              bra     $FC2DBC               Clear in port A

*******************************************************     dtroff, turn DTR off
FC2D88 7410              moveq.l #$10,D2               Bit 4
FC2D8A 600A              bra     $FC2D96               Set in port A

*******************************************************     dtron, turn DTR on
FC2D8C 74EF              moveq.l #$EF,D2               Bit 4
FC2D8E 602C              bra     $FC2DBC               Clear in port A

*******************************************************     ongibit, set bit(s) in sound chip port A
FC2D90 7400              moveq.l #0,D2
FC2D92 342F0004          move.w  4(A7),D2              Get bit pattern
FC2D96 48E7E000          movem.l D0-D2,-(A7)           Save registers
FC2D9A 40E7              move.w  SR, -(A7)             Save status
FC2D9C 007C0700          or.w    #$700,SR              IPL 7, disable interrupts
FC2DA0 720E              moveq.l #$E,D1                Read port A
FC2DA2 2F02              move.l  D2,-(A7)              Save bit pattern
FC2DA4 61AE              bsr     $FC2D54               Read port A
FC2DA6 241F              move.l  (A7)+,D2              Restore bit pattern
FC2DA8 8002              or.b    D2,D0                 OR bits to old value
FC2DAA 728E              moveq.l #$8E,D1               Write port A
FC2DAC 61A6              bsr     $FC2D54               Write new value
FC2DAE 46DF              move.w  (A7)+,SR              Restore status
FC2DB0 4CDF0007          movem.l (A7)+,D0-D2           Restore registers
FC2DB4 4E75              rts
```

```
*******************************************************    offgibit, clear bits in sound chip port A
FC2DB6 7400          moveq.l #0,D2
FC2DB8 342F0004      move.w  4(A7),D2              Bit pattern
FC2DBC 48E7E000      movem.l D0-D2,-(A7)           Save registers
FC2DC0 40E7          move.w  SR, -(A7)             Save status
FC2DC2 007C0700      or.w    #$700,SR              IPL 7, disable interrupts
FC2DC6 720E          moveq.l #$E,D1                Read port A
FC2DC8 2F02          move.l  D2,-(A7)              Save bit pattern
FC2DCA 6188          bsr     $FC2D54               Read port A
FC2DCC 241F          move.l  (A7)+,D2              Restore bit pattern
FC2DCE C002          and.b   D2,D0                 Clear bits
FC2DD0 728E          moveq.l #$8E,D1               Write to port A
FC2DD2 6180          bsr     $FC2D54               Write new value
FC2DD4 46DF          move.w  (A7)+,SR              Restore status
FC2DD6 4CDF0007      movem.l (A7)+,D0-D2           Restore registers
FC2DDA 4E75          rts

*******************************************************    initmouse
FC2DDC 4A6F0004      tst.w   4(A7)                 Turn mouse off?
FC2DE0 6726          beq     $FC2E08               Yes, disable mouse
FC2DE2 2B6F000A0DDC  move.l  10(A7),$DDC(A5)       Mouse interrpt vector
FC2DE8 266F0006      move.l  6(A7),A3              Address of the parameter block
FC2DEC 0C6F00010004  cmp.w   #1,4(A7)              Relative mouse ?
FC2DF2 6724          beq     $FC2E18               Yes
FC2DF4 0C6F00020004  cmp.w   #2,4(A7)              Absolute mouse ?
FC2DFA 6736          beq     $FC2E32               Yes
FC2DFC 0C6F00040004  cmp.w   #4,4(A7)              Keycode mouse ?
FC2E02 6770          beq     $FC2E74               Yes
FC2E04 7000          moveq.l #0,D0                 Error, invalid
FC2E06 4E75          rts
```

```
*****************************************************  disable mouse
FC2E08 7212              moveq.l #$12,D1              Disable mouse command
FC2E0A 6100F19C          bsr     $FC1FA8              Send to IKBD
FC2E0E 2B7C00FC2EDC0DDC  move.l  #$FC2EDC,$DDC(A5)    Mouse interrpt vector to rts
FC2E16 6070              bra     $FC2E88

*****************************************************  relative mouse
FC2E18 45ED0E28          lea     $E28(A5),A2          Transfer buffer pointer
FC2E1C 14FC0008          move.b  #8,(A2)+             Relative mouse
FC2E20 14FC000B          move.b  #$B,(A2)+            Relative mouse threshold x, y
FC2E24 6166              bsr     $FC2E8C              Set mouse parameters
FC2E26 7606              moveq.l #6,D3                Length of string - 1
FC2E28 45ED0E28          lea     $E28(A5),A2          Transfer buffer pointer
FC2E2C 6100F19A          bsr     $FC1FC8              Send string to IKBD
FC2E30 6056              bra     $FC2E88

*****************************************************  absolute mouse
FC2E32 45ED0E28          lea     $E28(A5),A2          Transfer buffer pointer
FC2E36 14FC0009          move.b  #9,(A2)+             Absolute mouse
FC2E3A 14EB0004          move.b  4(A3),(A2)+          xmax msb
FC2E3E 14EB0005          move.b  5(A3),(A2)+          xmax lsb
FC2E42 14EB0006          move.b  6(A3),(A2)+          ymax msb
FC2E46 14EB0007          move.b  7(A3),(A2)+          ymax lsb
FC2E4A 14FC000C          move.b  #$C,(A2)+            Absolute mouse scale
FC2E4E 613C              bsr     $FC2E8C              Set mouse parameters
FC2E50 14FC000E          move.b  #$E,(A2)+            Initial absolute mouse position
FC2E54 14FC0000          move.b  #0,(A2)+             Fill byte
FC2E58 14EB0008          move.b  8(A3),(A2)+          Start position x msb
FC2E5C 14EB0009          move.b  9(A3),(A2)+          Start position x lsb
FC2E60 14EB000A          move.b  10(A3),(A2)+         Start position y msb
FC2E64 14EB000B          move.b  11(A3),(A2)+         Start position y lsb
FC2E68 7610              moveq.l #16,D3               String length - 1
```

```
FC2E6A 45ED0E28           lea     $E28(A5),A2        Transfer buffer pointer
FC2E6E 6100F158           bsr     $FC1FC8            Send string to IKBD
FC2E72 6014               bra     $FC2E88

****************************************************  Keycode mouse
FC2E74 45ED0E28           lea     $E28(A5),A2        Transfer buffer pointer
FC2E78 14FC000A           move.b  #$A,(A2)+          Mouse keycode mode
FC2E7C 610E               bsr     $FC2E8C            Set mouse parameters
FC2E7E 7605               moveq.l #5,D3              Length of string - 1
FC2E80 45ED0E28           lea     $E28(A5),A2        Transfer buffer pointer
FC2E84 6100F142           bsr     $FC1FC8            Send string to IKBD
FC2E88 70FF               moveq.l #-1,D0             Flag for OK
FC2E8A 4E75               rts

****************************************************  setmouse, set mouse parameters
FC2E8C 14EB0002           move.b  2(A3),(A2)+        x threshold, scale, delta
FC2E90 14EB0003           move.b  3(A3),(A2)+        y threshold, scale, delta
FC2E94 7210               moveq.l #16,D1             top/bottom ?
FC2E96 922B0000           sub.b   (A3),D1
FC2E9A 14C1               move.b  D1,(A2)+
FC2E9C 14FC0007           move.b  #7,(A2)+
FC2EA0 14EB0001           move.b  1(A3),(A2)+
FC2EA4 4E75               rts

****************************************************  xbtimer, initialize timer
FC2EA6 7000               moveq.l #0,D0
FC2EA8 7200               moveq.l #0,D1              Clear registers
FC2EAA 7400               moveq.l #0,D2
FC2EAC 302F0004           move.w  4(A7),D0           Timer number (0-3 => A-D)
FC2EB0 322F0006           move.w  6(A7),D1           Value for control register
FC2EB4 342F0008           move.w  8(A7),D2           Value for date register
FC2EB8 6100F4AC           bsr     $FC2366            Set timer values
```

```
FC2EBC 4AAF000A           tst.l   10(A7)            Corresponding interrupt vector
FC2EC0 6B1A               bmi     $FC2EDC           not used?
FC2EC2 246F000A           move.l  10(A7),A2         Get vector
FC2EC6 7200               moveq.l #0,D1
FC2EC8 43F900FC2EDE       lea     $FC2EDE,A1        Table for determining interrupt number
FC2ECE 0280000000FF       and.l   #$FF,D0
FC2ED4 10310000           move.b  0(A1,D0.w),D0     Get interrupt number
FC2ED8 6100F542           bsr     $FC241C           initint, install interrupt
FC2EDC 4E75               rts

*****************************************************  Interrupt numbers of the MFP timer
FC2EDE 0D080504           dc.b    13,8,5,4

*****************************************************  keytrans, set keyboard tables
FC2EE2 4AAF0004           tst.l   4(A7)             Change standard table?
FC2EE6 6B06               bmi     $FC2EEE           No
FC2EE8 2B6F00040E1C       move.l  4(A7),$E1C(A5)    Address of the standard table
FC2EEE 4AAF0008           tst.l   8(A7)             Change shift table?
FC2EF2 6B06               bmi     $FC2EFA           No
FC2EF4 2B6F00080E20       move.l  8(A7),$E20(A5)    Address of the shift table
FC2EFA 4AAF000C           tst.l   12(A7)            Change Caps Lock table
FC2EFE 6B06               bmi     $FC2F06           No
FC2F00 2B6F000C0E24       move.l  12(A7),$E24(A5)   Address of the Caps Lock table
FC2F06 203C00000E1C       move.l  #$E1C,D0          Pointer to addresses of the tables
FC2F0C 4E75               rts

*****************************************************  bioskeys, standard keyboard table
FC2F0E 2B7C00FC20340E1C   move.l  #$FC2034,$E1C(A5) Standard table
FC2F16 2B7C00FC20B40E20   move.l  #$FC20B4,$E20(A5) Shift table
FC2F1E 2B7C00FC21340E24   move.l  #$FC2134,$E24(A5) Caps Lock table
FC2F26 4E75               rts
```

```
******************************************************  dosound, start sound
FC2F28 202D0E44         move.l  $E44(A5),D0             Get sound status
FC2F2C 222F0004         move.l  4(A7),D1                Address of the sound table
FC2F30 6B08             bmi     $FC2F3A                 Don't set
FC2F32 2B410E44         move.l  D1,$E44(A5)             New sound table
FC2F36 422D0E48         clr.b   $E48(A5)                Start sound timer
FC2F3A 4E75             rts

******************************************************  setprt, set/get printer configuration
FC2F3C 302D0E4A         move.w  $E4A(A5),D0             Old printer configuration
FC2F40 4A6F0004         tst.w   4(A7)                   New value negative?
FC2F44 6B06             bmi     $FC2F4C                 Yes, don't set
FC2F46 3B6F00040E4A     move.w  4(A7),$E4A(A5)          Set new value
FC2F4C 4E75             rts

******************************************************  kbrate, set/get keyboard repeat
FC2F4E 302D0E3C         move.w  $E3C(A5),D0             Delay before key repeat
FC2F52 4A6F0004         tst.w   4(A7)                   new value negative?
FC2F56 6B16             bmi     $FC2F6E                 Yes, don't set
FC2F58 322F0004         move.w  4(A7),D1                Get new value
FC2F5C 1B410E3C         move.b  D1,$E3C(A5)             and save
FC2F60 4A6F0006         tst.w   6(A7)                   Repeat rate
FC2F64 6B08             bmi     $FC2F6E                 Negative, don't set
FC2F66 322F0006         move.w  6(A7),D1                Get new value
FC2F6A 1B410E3D         move.b  D1,$E3D(A5)             and save
FC2F6E 4E75             rts

******************************************************  ikbdvecs, pointer to IKBD + MIDI vectors
FC2F70 203C00000DCC     move.l  #$DCC,D0                Address of the vector table
FC2F76 4E75             rts
```

```
******************************************************    timercint, timer C interrupt
FC2F78 52B9000004BA      addq.l   #1,$4BA                 _hz_200, increment 200 Hz counter
FC2F7E E7F900000E42      rol.w    $E42                    Rotate bit map
FC2F84 6A4E              bpl      $FC2FD4                 Not fourth interrupt, then done
FC2F86 48E7FFFE          movem.l  D0-D7/A0-A6,-(A7)       Save registers
FC2F8A 4BF900000000      lea      $0,A5                   Clear A5
FC2F90 614C              bsr      $FC2FDE                 Process sound
FC2F92 082D00010484      btst     #1,$484(A5)             conterm, key repeat enabled ?
FC2F98 672A              beq      $FC2FC4                 No
FC2F9A 4A2D0E39          tst.b    $E39(A5)                Key pressed ?
FC2F9E 6724              beq      $FC2FC4                 No
FC2FA0 4A2D0E3A          tst.b    $E3A(A5)                Counter for start delay
FC2FA4 6706              beq      $FC2FAC                 Not active
FC2FA6 532D0E3A          subq.b   #1,$E3A(A5)             decrement counter
FC2FAA 6618              bne      $FC2FC4                 Not run out?
FC2FAC 532D0E3B          subq.b   #1,$E3B(A5)             Decrement counter for repeat rate
FC2FB0 6612              bne      $FC2FC4                 Not run out?
FC2FB2 1B6D0E3D0E3B      move.b   $E3D(A5),$E3B(A5)       Reload counter
FC2FB8 102D0E39          move.b   $E39(A5),D0             Key to repeat
FC2FBC 41ED0DB0          lea      $DB0(A5),A0             Pointer to iorec keyboard
FC2FC0 6100FACE          bsr      $FC2A90                 Key code in keyboard buffer
FC2FC4 3F2D0442          move.w   $442(A5),-(A7)          _timer_ms
FC2FC8 206D0400          move.l   $400(A5),A0             etv_timer
FC2FCC 4E90              jsr      (A0)                    Execute routine
FC2FCE 544F              addq.w   #2,A7                   Correct stack pointer
FC2FD0 4CDF7FFF          movem.l  (A7)+,D0-D7/A0-A6       Restore register
FC2FD4 08B90005FFFFFA11  bclr     #5,$FFFFFA11            Clear interrupt service bit
FC2FDC 4E73              rte

******************************************************    sndirq, sound interrupt routine
FC2FDE 48E7C080          movem.l  D0-D1/A0,-(A7)          Save registers
FC2FE2 202D0E44          move.l   $E44(A5),D0             Pointer to sound table
```

```
FC2FE6 67000088       beq      $FC3070            No sound active?
FC2FEA 2040           move.l   D0,A0              Pointer to A0
FC2FEC 102D0E48       move.b   $E48(A5),D0        Load timer value
FC2FF0 6708           beq      $FC2FFA            New sound started?
FC2FF2 5300           subq.b   #1,D0              Else decrement timer
FC2FF4 1B400E48       move.b   D0,$E48(A5)        and store again
FC2FF8 6076           bra      $FC3070            Done
FC2FFA 1018           move.b   (A0)+,D0           Get sound command
FC2FFC 6B2E           bmi      $FC302C            Bit 7 set, special command
FC2FFE 13C0FFFF8800   move.b   D0,$FFFF8800       Select register in sound chip
FC3004 0C000007       cmp.b    #7,D0              Mixer ?
FC3008 661A           bne      $FC3024            No
FC300A 1218           move.b   (A0)+,D1           Data for mixer
FC300C 0201003F       and.b    #$3F,D1            Isolate bits 0-5
FC3010 1039FFFF8800   move.b   $FFFF8800,D0       Read mixer
FC3016 020000C0       and.b    #$C0,D0            Isolate bits 6-7
FC301A 8001           or.b     D1,D0              OR with sound data
FC301C 13C0FFFF8802   move.b   D0,$FFFF8802       and write in register
FC3022 60D6           bra      $FC2FFA            Next sound command
FC3024 13D8FFFF8802   move.b   (A0)+,$FFFF8802    Write byte directly in sound chip
FC302A 60CE           bra      $FC2FFA            Next sound command
FC302C 5200           addq.b   #1,D0              Was command $FF ?
FC302E 6A32           bpl      $FC3062            Yes
FC3030 0C000081       cmp.b    #$81,D0            Was command $80 ?
FC3034 6606           bne      $FC303C            No
FC3036 1B580E49       move.b   (A0)+,$E49(A5)     Save byte for later
FC303A 60BE           bra      $FC2FFA            Next sound command
FC303C 0C000082       cmp.b    #$82,D0            Was command $81 ?
FC3040 6620           bne      $FC3062            No
FC3042 13D8FFFF8800   move.b   (A0)+,$FFFF8800    Select register
FC3048 1018           move.b   (A0)+,D0           Increment value
FC304A D12D0E49       add.b    D0,$E49(A5)        Add
```

```
FC304E 1018              move.b   (A0)+,D0             End value
FC3050 13ED0E49FFFF8802  move.b   $E49(A5),$FFFF8802   Write temp value in sound chip
FC3058 B02D0E49          cmp.b    $E49(A5),D0          End value reached?
FC305C 670E              beq      $FC306C              Yes
FC305E 5948              subq.w   #4,A0                Sound back to same command
FC3060 600A              bra      $FC306C
FC3062 1B580E48          move.b   (A0)+,$E48(A5)       Next value as delay timer
FC3066 6604              bne      $FC306C
FC3068 307C0000          move.w   #0,A0                Clear sound pointer
FC306C 2B480E44          move.l   A0,$E44(A5)          Save current sound pointer
FC3070 4CDF0103          movem.l  (A7)+,D0-D1/A0       Restore registers
FC3074 4E75              rts

*********************************************************  bellsnd, sound for CTRL G
FC3076 0034              dc.b     0,$34
FC3078 0100              dc.b     1,0
FC307A 0200              dc.b     2,0
FC307C 0300              dc.b     3,0
FC307E 0400              dc.b     4,0
FC3080 0500              dc.b     5,0
FC3082 0600              dc.b     6,0
FC3084 07FE              dc.b     7,$FE
FC3086 0810              dc.b     8,10
FC3088 0900              dc.b     9,0
FC308A 0A00              dc.b     10,0
FC308C 0B00              dc.b     11,0
FC308E 0C10              dc.b     12,16
FC3090 0D09              dc.b     13,9
FC3092 FF00              dc.b     $FF,0
```

```
*****************************************************   keyclick, sound on key click
FC3094 003B           dc.b     0,$3B
FC3096 0100           dc.b     1,0
FC3098 0200           dc.b     2,0
FC309A 0300           dc.b     3,0
FC309C 0400           dc.b     4,0
FC309E 0500           dc.b     5,0
FC30A0 0600           dc.b     6,0
FC30A2 07FE           dc.b     7,$FE
FC30A4 0810           dc.b     8,16
FC30A6 0D03           dc.b     13,3
FC30A8 0B80           dc.b     11,$80
FC30AA 0C01           dc.b     12,1
FC30AC FF00           dc.b     $FF,0

*****************************************************   prtblk, hardcopy
FC30AE 4E560000           link     A6,#0
FC30B2 48E7070C           movem.l D5-D7/A4-A5,-(A7)     Save registers
FC30B6 2A6E0008           move.l   8(A6),A5             Address of the parameter block
FC30BA 287C000029BE       move.l   #$29BE,A4            Address of the working memory
FC30C0 7E1E               moveq.l #30,D7                30 bytes
FC30C2 6004               bra      $FC30C8
FC30C4 18DD               move.b   (A5)+,(A4)+          Copy parameters in working memory
FC30C6 5347               subq.w   #1,D7
FC30C8 4A47               tst.w    D7
FC30CA 6EF8               bgt      $FC30C4              Next byte
FC30CC 0C790001000029D6   cmp.w    #1,$29D6             p_port
FC30D4 630E               bls      $FC30E4              0 or 1 ?
FC30D6 33FCFFFF000004EE   move.w   #-1,$4EE             Clear _dumpflg
FC30DE 70FF               moveq.l #-1,D0                Flag for error
FC30E0 60000F6C           bra      $FC404E              Terminate
```

```
FC30E4 4A79000029D6       tst.w    $29D6          p_port
FC30EA 6704               beq      $FC30F0        Centronics ?
FC30EC 4240               clr.w    D0             0 = RS 232
FC30EE 6002               bra      $FC30F2
FC30F0 7001               moveq.l  #1,D0          1 = Centronics
FC30F2 13C0000029BC       move.b   D0,$29BC       Save printer port
FC30F8 4A79000029C6       tst.w    $29C6          p_height
FC30FE 6654               bne      $FC3154        Not zero?
FC3100 6032               bra      $FC3134        Else just dump p_width bytes

FC3102 0C790001000004EE   cmp.w    #1,$4EE        _dumpflg to one?
FC310A 663A               bne      $FC3146        Terminate hardcopy?
FC310C 2079000029BE       move.l   $29BE,A0       p_blkptr, screen address
FC3112 1010               move.b   (A0),D0        Get byte
FC3114 4880               ext.w    D0
FC3116 3E80               move.w   D0,(A7)        on the stack
FC3118 61000F3E           bsr      $FC4058        Output character
FC311C 52B9000029BE       addq.l   #1,$29BE       Increment p_blkptr
FC3122 4A40               tst.w    D0             Output OK ?
FC3124 670E               beq      $FC3134        Yes
FC3126 33FCFFFF000004EE   move.w   #-1,$4EE       Clear _dumpflg
FC312E 70FF               moveq.l  #-1,D0         Flag for error
FC3130 60000F1C           bra      $FC404E        Terminate

FC3134 4240               clr.w    D0
FC3136 3039000029C4       move.w   $29C4,D0       p_width
FC313C 5379000029C4       subq.w   #1,$29C4       Decrement p_width
FC3142 4A40               tst.w    D0             Not zero yet?
FC3144 66BC               bne      $FC3102        Output next character
FC3146 33FCFFFF000004EE   move.w   #-1,$4EE       Clear _dumpflg
FC314E 4240               clr.w    D0             OK
FC3150 60000EFC           bra      $FC404E        Terminate
```

```
FC3154 0C790003000029D4    cmp.w    #3,$29D4       p_type
FC315C 630E                bls      $FC316C        OK ?
FC315E 33FCFFFF000004EE    move.w   #-1,$4EE       Clear _dumpflg
FC3166 70FF                moveq.l  #-1,D0         Flag for error
FC3168 60000EE4            bra      $FC404E        Terminate

FC316C 0C790001000029CE    cmp.w    #1,$29CE       p_destres, printer resolution
FC3174 630E                bls      $FC3184        OK ?
FC3176 33FCFFFF000004EE    move.w   #-1,$4EE       Clear _dumpflg
FC317E 70FF                moveq.l  #-1,D0         Flag for error
FC3180 60000ECC            bra      $FC404E        Terminate

FC3184 0C790002000029CC    cmp.w    #2,$29CC       p_srcres, screen resolution
FC318C 630E                bls      $FC319C        OK ?
FC318E 33FCFFFF000004EE    move.w   #-1,$4EE       Clear _dumpflg
FC3196 70FF                moveq.l  #-1,D0         Flag for error
FC3198 60000EB4            bra      $FC404E        Terminate

FC319C 0C790007000029C2    cmp.w    #7,$29C2       p_offset
FC31A4 630E                bls      $FC31B4        OK ?
FC31A6 33FCFFFF000004EE    move.w   #-1,$4EE       Clear _dumpflg
FC31AE 70FF                moveq.l  #-1,D0         Flag for error
FC31B0 60000E9C            bra      $FC404E        Terminate

FC31B4 4A79000029CC        tst.w    $29CC          p_srcres, screen resolution
FC31BA 6704                beq      $FC31C0        Low resolution ?
FC31BC 4240                clr.w    D0
FC31BE 6002                bra      $FC31C2
FC31C0 7001                moveq.l  #1,D0
FC31C2 13C00000609A        move.b   D0,$609A       Flag for low resolution
FC31C8 0C790001000029CC    cmp.w    #1,$29CC       p_srcres, screen resolution
FC31D0 6704                beq      $FC31D6        Medium resolution ?
```

```
FC31D2 4240             clr.w    D0
FC31D4 6002             bra      $FC31D8
FC31D6 7001             moveq.l  #1,D0
FC31D8 13C000005FE4     move.b   D0,$5FE4      Flag for medium resolution
FC31DE 0C790002000029CC cmp.w    #2,$29CC      p_srcres, screen resolution
FC31E6 6704             beq      $FC31EC       High resolution ?
FC31E8 4240             clr.w    D0
FC31EA 6002             bra      $FC31EE
FC31EC 7001             moveq.l  #1,D0
FC31EE 13C000005FE6     move.b   D0,$5FE6      Flag for high resolution
FC31F4 4A79000029CE     tst.w    $29CE         p_destres, printer resolution
FC31FA 6704             beq      $FC3200       Test mode?
FC31FC 4240             clr.w    D0            Quality mode
FC31FE 6002             bra      $FC3202
FC3200 7001             moveq.l  #1,D0
FC3202 13C000005FFE     move.b   D0,$5FFE      Flag for mode
FC3208 0C790001000029D4 cmp.w    #1,$29D4      p_type, ATARI color dot-matrix printer?
FC3210 6704             beq      $FC3216       Yes
FC3212 4240             clr.w    D0
FC3214 6002             bra      $FC3218
FC3216 7001             moveq.l  #1,D0
FC3218 13C00000575E     move.b   D0,$575E      Flag for ATARI color dot-matrix printer
FC321E 0C790002000029D4 cmp.w    #2,$29D4      p_type, ATARI daisy-wheel printer?
FC3226 6704             beq      $FC322C
FC3228 4240             clr.w    D0
FC322A 6002             bra      $FC322E
FC322C 7001             moveq.l  #1,D0
FC322E 13C00000609C     move.b   D0,$609C      Flag for ATARI daisy-wheel printer
FC3234 0C790003000029D4 cmp.w    #3,$29D4      p_type, Epson B/W dot-matrix printer?
FC323C 6704             beq      $FC3242       Yes
FC323E 4240             clr.w    D0            Else ATARI B/W matrix printer
FC3240 6002             bra      $FC3244
```

```
FC3242 7001              moveq.l #1,D0
FC3244 13C000005780      move.b  D0,$5780        Flag for Epson B/W dot matrix printer
FC324A 4A390000609C      tst.b   $609C           ATARI daisy wheel?
FC3250 670E              beq     $FC3260         No
FC3252 33FCFFFF000004EE  move.w  #-1,$4EE        Clear _dumpflg
FC325A 70FF              moveq.l #-1,D0          Flag for error
FC325C 60000DF0          bra     $FC404E         Terminate

FC3260 4A3900005780      tst.b   $5780           Epson B/W dot-matrix?
FC3266 670C              beq     $FC3274         No
FC3268 4A3900005FFE      tst.b   $5FFE           Quality mode?
FC326E 6604              bne     $FC3274         No
FC3270 7001              moveq.l #1,D0
FC3272 6008              bra     $FC327C
FC3274 103900005FFE      move.b  $5FFE,D0        Quality mode
FC327A 4880              ext.w   D0
FC327C 13C000005FFE      move.b  D0,$5FFE        Quality mode
FC3282 4A390000609A      tst.b   $609A           Low resolution ?
FC3288 6726              beq     $FC32B0         No
FC328A 0C79014000029C4   cmp.w   #320,$29C4      p_width
FC3292 631C              bls     $FC32B0
FC3294 4240              clr.w   D0
FC3296 3039000029C4      move.w  $29C4,D0        p_width
FC329C D07CFEC0          add.w   #-320,D0
FC32A0 D179000029CA      add.w   D0,$29CA        p_right
FC32A6 33FC0140000029C4  move.w  #320,$29C4      p_width
FC32AE 6024              bra     $FC32D4
FC32B0 0C790280000029C4  cmp.w   #640,$29C4      p_width
FC32B8 631A              bls     $FC32D4
FC32BA 4240              clr.w   D0
FC32BC 3039000029C4      move.w  $29C4,D0        p_width
FC32C2 D07CFD80          add.w   #-640,D0
```

```
FC32C6 D179000029CA          add.w    D0,$29CA            p_right
FC32CC 33FC0280000029C4      move.w   #640,$29C4          p_width
FC32D4 4AB9000029D8          tst.l    $29D8               p_masks, half-tone mask
FC32DA 6614                  bne      $FC32F0
FC32DC 23FC00FD1BAC000029D8  move.l   #$FD1BAC,$29D8      Use default mask
FC32E6 13FC000100004DBA      move.b   #1,$4DBA
FC32EE 6006                  bra      $FC32F6
FC32F0 423900004DBA          clr.b    $4DBA
FC32F6 4A3900005FE6          tst.b    $5FE6               High resolution ?
FC32FC 6718                  beq      $FC3316             No
FC32FE 2079000029D0          move.l   $29D0,A0            p_colpal
FC3304 4240                  clr.w    D0
FC3306 3010                  move.w   (A0),D0             Get color
FC3308 C07C0001              and.w    #1,D0
FC330C 33C00000608C          move.w   D0,$608C
FC3312 60000290              bra      $FC35A4
FC3316 4247                  clr.w    D7                  Clear counter for running color
FC3318 60000282              bra      $FC359C             To loop end

FC331C 2079000029D0          move.l   $29D0,A0            colpal, address of color palette
FC3322 4240                  clr.w    D0
FC3324 3010                  move.w   (A0),D0             Get color
FC3326 C07C0777              and.w    #$777,D0            Mask irrelevant bits
FC332A 33C00000574A          move.w   D0,$574A            Mask color
FC3330 54B9000029D0          addq.l   #2,$29D0            Poiner to next color
FC3336 0C7907770000574A      cmp.w    #$777,$574A         Color equals white?
FC333E 67000230              beq      $FC3570             Yes
FC3342 30390000574A          move.w   $574A,D0            Load color
FC3348 C07C0007              and.w    #7,D0               Isolate blue level
FC334C 33C000004150          move.w   D0,$4150            And save
FC3352 30390000574A          move.w   $574A,D0            Load color
FC3358 E840                  asr.w    #4,D0
```

```
FC335A C07C0007          and.w    #7,D0              Isolate green level
FC335E 33C000005FE8      move.w   D0,$5FE8           and save
FC3364 30390000574A      move.w   $574A,D0           Load color
FC336A E040              asr.w    #8,D0
FC336C C07C0007          and.w    #7,D0              Isolate red level
FC3370 33C000005624      move.w   D0,$5624           and save
FC3376 4A390000575E      tst.b    $575E              ATARI color dot-matrix printer?
FC337C 670001A0          beq      $FC351E            No
FC3380 3047              move.w   D7,A0
FC3382 D1C8              add.l    A0,A0
FC3384 D1FC00005760      add.l    #$5760,A0
FC338A 30B900005624      move.w   $5624,(A0)         Red level
FC3390 3047              move.w   D7,A0
FC3392 D1C8              add.l    A0,A0
FC3394 227C00005760      move.l   #$5760,A1
FC339A 30309800          move.w   0(A0,A1.l),D0
FC339E B07900005FE8      cmp.w    $5FE8,D0           Green level
FC33A4 6C08              bge      $FC33AE
FC33A6 303900005FE8      move.w   $5FE8,D0           Green level
FC33AC 600E              bra      $FC33BC
FC33AE 3047              move.w   D7,A0
FC33B0 D1C8              add.l    A0,A0
FC33B2 227C00005760      move.l   #$5760,A1
FC33B8 30309800          move.w   0(A0,A1.l),D0
FC33BC 3247              move.w   D7,A1
FC33BE D3C9              add.l    A1,A1
FC33C0 D3FC00005760      add.l    #$5760,A1
FC33C6 3280              move.w   D0,(A1)
FC33C8 3047              move.w   D7,A0
FC33CA D1C8              add.l    A0,A0
FC33CC 227C00005760      move.l   #$5760,A1
FC33D2 30309800          move.w   0(A0,A1.l),D0
```

```
FC33D6 B07900004150      cmp.w    $4150,D0          Blue level
FC33DC 6C08              bge      $FC33E6
FC33DE 303900004150      move.w   $4150,D0          Blue level
FC33E4 600E              bra      $FC33F4
FC33E6 3047              move.w   D7,A0
FC33E8 D1C8              add.l    A0,A0
FC33EA 227C00005760      move.l   #$5760,A1
FC33F0 30309800          move.w   0(A0,A1.l),D0
FC33F4 3247              move.w   D7,A1
FC33F6 D3C9              add.l    A1,A1
FC33F8 D3FC00005760      add.l    #$5760,A1
FC33FE 3280              move.w   D0,(A1)
FC3400 3047              move.w   D7,A0
FC3402 D1C8              add.l    A0,A0
FC3404 D1FC00005760      add.l    #$5760,A0
FC340A 5250              addq.w   #1,(A0)
FC340C 3047              move.w   D7,A0
FC340E D1C8              add.l    A0,A0
FC3410 D1FC00006002      add.l    #$6002,A0
FC3416 30B900005624      move.w   $5624,(A0)        Red level
FC341C 3047              move.w   D7,A0
FC341E D1C8              add.l    A0,A0
FC3420 227C00006002      move.l   #$6002,A1
FC3426 30309800          move.w   0(A0,A1.l),D0
FC342A B07900005FE8      cmp.w    $5FE8,D0          Green level
FC3430 6F08              ble      $FC343A
FC3432 303900005FE8      move.w   $5FE8,D0          Green level
FC3438 600E              bra      $FC3448
FC343A 3047              move.w   D7,A0
FC343C D1C8              add.l    A0,A0
FC343E 227C00006002      move.l   #$6002,A1
FC3444 30309800          move.w   0(A0,A1.l),D0
```

```
FC3448 3247              move.w  D7,A1
FC344A D3C9              add.l   A1,A1
FC344C D3FC00006002      add.l   #$6002,A1
FC3452 3280              move.w  D0,(A1)
FC3454 3047              move.w  D7,A0
FC3456 D1C8              add.l   A0,A0
FC3458 227C00006002      move.l  #$6002,A1
FC345E 30309800          move.w  0(A0,A1.l),D0
FC3462 B07900004150      cmp.w   $4150,D0            Green level
FC3468 6F08              ble     $FC3472
FC346A 303900004150      move.w  $4150,D0            Green level
FC3470 600E              bra     $FC3480
FC3472 3047              move.w  D7,A0
FC3474 D1C8              add.l   A0,A0
FC3476 227C00006002      move.l  #$6002,A1
FC347C 30309800          move.w  0(A0,A1.l),D0
FC3480 3247              move.w  D7,A1
FC3482 D3C9              add.l   A1,A1
FC3484 D3FC00006002      add.l   #$6002,A1
FC348A 3280              move.w  D0,(A1)
FC348C 303900005624      move.w  $5624,D0            Red level
FC3492 3247              move.w  D7,A1
FC3494 D3C9              add.l   A1,A1
FC3496 D3FC00006002      add.l   #$6002,A1
FC349C 3211              move.w  (A1),D1
FC349E 5241              addq.w  #1,D1
FC34A0 9041              sub.w   D1,D0
FC34A2 6E04              bgt     $FC34A8
FC34A4 4240              clr.w   D0
FC34A6 6002              bra     $FC34AA
FC34A8 7001              moveq.l #1,D0
FC34AA 33C000005624      move.w  D0,$5624            Red level
```

```
FC34B0 303900005FE8     move.w   $5FE8,D0       Green level
FC34B6 3247             move.w   D7,A1
FC34B8 D3C9             add.l    A1,A1
FC34BA D3FC00006002     add.l    #$6002,A1
FC34C0 3211             move.w   (A1),D1
FC34C2 5241             addq.w   #1,D1
FC34C4 9041             sub.w    D1,D0
FC34C6 6E04             bgt      $FC34CC
FC34C8 4240             clr.w    D0
FC34CA 6002             bra      $FC34CE
FC34CC 7001             moveq.l  #1,D0
FC34CE 33C000005FE8     move.w   D0,$5FE8       Green level
FC34D4 303900004150     move.w   $4150,D0       Blue level
FC34DA 3247             move.w   D7,A1
FC34DC D3C9             add.l    A1,A1
FC34DE D3FC00006002     add.l    #$6002,A1
FC34E4 3211             move.w   (A1),D1
FC34E6 5241             addq.w   #1,D1
FC34E8 9041             sub.w    D1,D0
FC34EA 6E04             bgt      $FC34F0
FC34EC 4240             clr.w    D0
FC34EE 6002             bra      $FC34F2
FC34F0 7001             moveq.l  #1,D0
FC34F2 33C000004150     move.w   D0,$4150       Blue level
FC34F8 303900005624     move.w   $5624,D0       Red level
FC34FE E540             asl.w    #2,D0          times 4
FC3500 323900005FE8     move.w   $5FE8,D1       Green level
FC3506 E341             asl.w    #1,D1          times 2
FC3508 D041             add.w    D1,D0          Add to red level
FC350A D07900004150     add.w    $4150,D0       Add blue level
FC3510 3247             move.w   D7,A1
FC3512 D3C9             add.l    A1,A1
```

```
FC3514 D3FC00005628         add.l   #$5628,A1
FC351A 3280                 move.w  D0,(A1)
FC351C 6050                 bra     $FC356E
FC351E 303900005624         move.w  $5624,D0              Red level
FC3524 C1FC001E             muls.w  #$1E,D0               times 30, weighting 30 %
FC3528 323900005FE8         move.w  $5FE8,D1              Green level
FC352E C3FC003B             muls.w  #$3B,D1               times 59, weighting 59 %
FC3532 D041                 add.w   D1,D0
FC3534 323900004150         move.w  $4150,D1              Blue level
FC353A C3FC000B             muls.w  #$B,D1                times 11, weighting 11 %
FC353E D041                 add.w   D1,D0
FC3540 48C0                 ext.l   D0
FC3542 81FC0064             divs.w  #$64,D0               divided by 100, scaling
FC3546 3247                 move.w  D7,A1
FC3548 D3C9                 add.l   A1,A1
FC354A D3FC00006002         add.l   #$6002,A1
FC3550 3280                 move.w  D0,(A1)
FC3552 3047                 move.w  D7,A0
FC3554 D1C8                 add.l   A0,A0
FC3556 D1FC00005628         add.l   #$5628,A0
FC355C 30BC0007             move.w  #7,(A0)
FC3560 3047                 move.w  D7,A0
FC3562 D1C8                 add.l   A0,A0
FC3564 D1FC00005760         add.l   #$5760,A0
FC356A 30BC0008             move.w  #8,(A0)
FC356E 602A                 bra     $FC359A
FC3570 3047                 move.w  D7,A0
FC3572 D1C8                 add.l   A0,A0
FC3574 D1FC00006002         add.l   #$6002,A0
FC357A 30BC0008             move.w  #8,(A0)
FC357E 3047                 move.w  D7,A0
FC3580 D1C8                 add.l   A0,A0
```

```
FC3582 D1FC00005628         add.l    #$5628,A0
FC3588 30BC0007             move.w   #7,(A0)
FC358C 3047                 move.w   D7,A0
FC358E D1C8                 add.l    A0,A0
FC3590 D1FC00005760         add.l    #$5760,A0
FC3596 30BC0008             move.w   #8,(A0)
FC359A 5247                 addq.w   #1,D7               Next color
FC359C BE7C0010             cmp.w    #$10,D7             16 colors?
FC35A0 6D00FD7A             blt      $FC331C             No, next color
FC35A4 4A390000609A         tst.b    $609A               Low resolution ?
FC35AA 6716                 beq      $FC35C2             No
FC35AC 7004                 moveq.l  #4,D0               Four points per screen point
FC35AE 33C000006022         move.w   D0,$6022
FC35B4 33C000005FF8         move.w   D0,$5FF8
FC35BA 33C0000056F8         move.w   D0,$56F8
FC35C0 6038                 bra      $FC35FA
FC35C2 4A3900005FE4         tst.b    $5FE4               Medium resolution ?
FC35C8 6718                 beq      $FC35E2             No
FC35CA 7002                 moveq.l  #2,D0               2 points per screen point
FC35CC 33C000006022         move.w   D0,$6022
FC35D2 33C0000056F8         move.w   D0,$56F8
FC35D8 33FC000400005FF8     move.w   #4,$5FF8
FC35E0 6018                 bra      $FC35FA
FC35E2 33FC0001000056F8     move.w   #1,$56F8
FC35EA 33FC000800005FF8     move.w   #8,$5FF8
FC35F2 33FC000200006022     move.w   #2,$6022
FC35FA 4A3900005780         tst.b    $5780               Epson B/W dot matrix printer?
FC3600 6706                 beq      $FC3608             No
FC3602 3F3C0002             move.w   #2,-(A7)
FC3606 6004                 bra      $FC360C
FC3608 3F3C0001             move.w   #1,-(A7)
FC360C 303900006022         move.w   $6022,D0
```

```
FC3612 48C0               ext.l    D0
FC3614 81DF               divs.w   (A7)+,D0
FC3616 33C000006022       move.w   D0,$6022
FC361C 4240               clr.w    D0
FC361E 3039000029C8       move.w   $29C8,D0              p_left
FC3624 D079000029C4       add.w    $29C4,D0              p_width
FC362A D079000029CA       add.w    $29CA,D0              p_right
FC3630 C0F9000056F8       mulu.w   $56F8,D0
FC3636 E848               lsr.w    #4,D0                 divided by 16
FC3638 33C000005626       move.w   D0,$5626
FC363E 303900005626       move.w   $5626,D0
FC3644 C1F900005FF8       muls.w   $5FF8,D0
FC364A 33C000004E10       move.w   D0,$4E10
FC3650 2039000029BE       move.l   $29BE,D0              p_blkptr, screen address
FC3656 C0BCFFFFFFFE       and.l    #$FFFFFFFE,D0         Even address
FC365C 23C000005648       move.l   D0,$5648              save
FC3662 2039000029BE       move.l   $29BE,D0              p_blkptr
FC3668 B0B900005648       cmp.l    $5648,D0
FC366E 660A               bne      $FC367A
FC3670 4240               clr.w    D0
FC3672 3039000029C2       move.w   $29C2,D0              p_offset
FC3678 600A               bra      $FC3684
FC367A 4240               clr.w    D0
FC367C 3039000029C2       move.w   $29C2,D0              p_offset
FC3682 5040               addq.w   #8,D0
FC3684 33C00000574C       move.w   D0,$574C
FC368A 13FC0001000060A0   move.b   #1,$60A0
FC3692 4279000016A8       clr.w    $16A8
FC3698 60000976           bra      $FC4010
FC369C 0C790001000004EE   cmp.w    #1,$4EE               _dumpflg at one?
FC36A4 6600097C           bne      $FC4022
FC36A8 4A3900004DBA       tst.b    $4DBA
```

```
FC36AE 6700018E                beq      $FC383E
FC36B2 13FC0001000041B6        move.b   #1,$41B6
FC36BA 4240                    clr.w    D0
FC36BC 3039000029C4            move.w   $29C4,D0             p_width
FC36C2 C0F9000056F8            mulu.w   $56F8,D0
FC36C8 E848                    lsr.w    #4,D0
FC36CA 9079000056F8            sub.w    $56F8,D0
FC36D0 E348                    lsl.w    #1,D0
FC36D2 4840                    swap     D0
FC36D4 4240                    clr.w    D0
FC36D6 4840                    swap     D0
FC36D8 D0B900005648            add.l    $5648,D0
FC36DE 23C000005FEA            move.l   D0,$5FEA
FC36E4 700F                    moveq.l  #15,D0
FC36E6 4241                    clr.w    D1
FC36E8 3239000029C4            move.w   $29C4,D1             p_width
FC36EE C27C000F                and.w    #$F,D1
FC36F2 9041                    sub.w    D1,D0
FC36F4 33C000006028            move.w   D0,$6028
FC36FA 33F9000029C400004DBC    move.w   $29C4,$4DBC          p_width
FC3704 6000012C                bra      $FC3832

FC3708 4240                    clr.w    D0
FC370A 3039000029C6            move.w   $29C6,D0             p_height
FC3710 9079000016A8            sub.w    $16A8,D0
FC3716 4840                    swap     D0
FC3718 4240                    clr.w    D0
FC371A 4840                    swap     D0
FC371C 80F900005FF8            divu.w   $5FF8,D0
FC3722 6708                    beq      $FC372C
FC3724 303900005FF8            move.w   $5FF8,D0
FC372A 600E                    bra      $FC373A
```

```
FC372C 4240                 clr.w    D0
FC372E 3039000029C6         move.w   $29C6,D0             p_height
FC3734 9079000016A8         sub.w    $16A8,D0
FC373A 33C000005FE0         move.w   D0,$5FE0
FC3740 23F900005FEA000058EC move.l   $5FEA,$58EC
FC374A 4247                 clr.w    D7
FC374C 600000A6             bra      $FC37F4
FC3750 427900006030         clr.w    $6030
FC3756 33FC000100006024     move.w   #1,$6024
FC375E 23F9000058EC0000574E move.l   $58EC,$574E
FC3768 4246                 clr.w    D6
FC376A 6030                 bra      $FC379C
FC376C 20790000574E         move.l   $574E,A0
FC3772 3010                 move.w   (A0),D0
FC3774 720F                 moveq.l  #15,D1
FC3776 927900006028         sub.w    $6028,D1
FC377C E260                 asr.w    D1,D0
FC377E C07C0001             and.w    #1,D0
FC3782 C1F900006024         muls.w   $6024,D0
FC3788 D17900006030         add.w    D0,$6030
FC378E 54B90000574E         addq.l   #2,$574E
FC3794 E1F900006024         asl.w    $6024
FC379A 5246                 addq.w   #1,D6
FC379C BC79000056F8         cmp.w    $56F8,D6
FC37A2 6DC8                 blt      $FC376C
FC37A4 4A3900005FE6         tst.b    $5FE6                High resolution ?
FC37AA 671A                 beq      $FC37C6              No
FC37AC 303900006030         move.w   $6030,D0
FC37B2 32390000608C         move.w   $608C,D1
FC37B8 B340                 eor.w    D1,D0
FC37BA 6608                 bne      $FC37C4
FC37BC 4239000041B6         clr.b    $41B6
```

```
FC37C2 603A                 bra       $FC37FE
FC37C4 601C                 bra       $FC37E2
FC37C6 307900006030         move.w    $6030,A0
FC37CC D1C8                 add.l     A0,A0
FC37CE D1FC00006002         add.l     #$6002,A0
FC37D4 0C500008             cmp.w     #8,(A0)
FC37D8 6708                 beq       $FC37E2
FC37DA 4239000041B6         clr.b     $41B6
FC37E0 601C                 bra       $FC37FE
FC37E2 303900005626         move.w    $5626,D0
FC37E8 E340                 asl.w     #1,D0
FC37EA 48C0                 ext.l     D0
FC37EC D1B9000058EC         add.l     D0,$58EC
FC37F2 5247                 addq.w    #1,D7
FC37F4 BE7900005FE0         cmp.w     $5FE0,D7
FC37FA 6D00FF54             blt       $FC3750
FC37FE 4A39000041B6         tst.b     $41B6
FC3804 6736                 beq       $FC383C
FC3806 537900006028         subq.w    #1,$6028
FC380C 4A7900006028         tst.w     $6028
FC3812 6C18                 bge       $FC382C
FC3814 3039000056F8         move.w    $56F8,D0
FC381A E340                 asl.w     #1,D0
FC381C 48C0                 ext.l     D0
FC381E 91B900005FEA         sub.l     D0,$5FEA
FC3824 33FC000F00006028     move.w    #$F,$6028
FC382C 537900004DBC         subq.w    #1,$4DBC
FC3832 4A7900004DBC         tst.w     $4DBC
FC3838 6E00FECE             bgt       $FC3708
FC383C 600A                 bra       $FC3848
FC383E 33F9000029C400004DBC move.w    $29C4,$4DBC           p_width
FC3848 3E3900004DBC         move.w    $4DBC,D7
```

```
FC384E CFF900006022    muls.w   $6022,D7
FC3854 4A3900005780    tst.b    $5780           Epson B/W dot-matrix printer?
FC385A 670A            beq      $FC3866         No
FC385C 3007            move.w   D7,D0
FC385E 48C0            ext.l    D0
FC3860 81FC0002        divs.w   #2,D0
FC3864 6002            bra      $FC3868
FC3866 4240            clr.w    D0
FC3868 DE40            add.w    D0,D7
FC386A 3007            move.w   D7,D0           Number of points
FC386C 48C0            ext.l    D0
FC386E 81FC0100        divs.w   #$100,D0        divided by 256
FC3872 4840            swap     D0              remainder
FC3874 13C000004E16    move.b   D0,$4E16        Number of points, low byte
FC387A 3007            move.w   D7,D0           Number of points
FC387C 48C0            ext.l    D0
FC387E 81FC0100        divs.w   #$100,D0        divided by 256
FC3882 13C000004E18    move.b   D0,$4E18        Number of points, high byte
FC3888 427900005782    clr.w    $5782
FC388E 60000656        bra      $FC3EE6
FC3892 4279000060A2    clr.w    $60A2
FC3898 600005F0        bra      $FC3E8A
FC389C 4A390000575E    tst.b    $575E           ATARI color dot-matrix printer?
FC38A2 67000076        beq      $FC391A         No
FC38A6 4A3900005FE6    tst.b    $5FE6           High resolution ?
FC38AC 6600006C        bne      $FC391A         Yes
FC38B0 4A79000060A2    tst.w    $60A2
FC38B6 661E            bne      $FC38D6
FC38B8 2EBC00FD1BBE    move.l   #$FD1BBE,(A7)   ESC 'X', 6
FC38BE 610007E4        bsr      $FC40A4         Send string to printer
FC38C2 4A40            tst.w    D0              Output OK?
```

```
FC38C4 670E             beq      $FC38D4            Yes
FC38C6 33FCFFFF000004EE move.w   #-1,$4EE           Clear _dumpflg
FC38CE 70FF             moveq.l  #-1,D0             Flag for error
FC38D0 6000077C         bra      $FC404E            Terminate

FC38D4 6044             bra      $FC391A

FC38D6 0C790001000060A2 cmp.w    #1,$60A2
FC38DE 661E             bne      $FC38FE
FC38E0 2EBC00FD1BC3     move.l   #$FD1BC3,(A7)      ESC 'X', 5
FC38E6 610007BC         bsr      $FC40A4            Send string to printer
FC38EA 4A40             tst.w    D0                 Output OK?
FC38EC 670E             beq      $FC38FC            Yes
FC38EE 33FCFFFF000004EE move.w   #-1,$4EE           Clear _dumpflg
FC38F6 70FF             moveq.l  #-1,D0             Flag for error
FC38F8 60000754         bra      $FC404E            Terminate

FC38FC 601C             bra      $FC391A

FC38FE 2EBC00FD1BC8     move.l   #$FD1BC8,(A7)      ESC 'X', 3
FC3904 6100079E         bsr      $FC40A4            Send string to printer
FC3908 4A40             tst.w    D0                 Output OK?
FC390A 670E             beq      $FC391A            Yes
FC390C 33FCFFFF000004EE move.w   #-1,$4EE           Clear _dumpflg
FC3914 70FF             moveq.l  #-1,D0             Flag for error
FC3916 60000736         bra      $FC404E            Terminate

FC391A 4A3900005780     tst.b    $5780              Epson B/W dot-matrix printer?
FC3920 6708             beq      $FC392A            No
FC3922 2EBC00FD1BCD     move.l   #$FD1BCD,(A7)      ESC 'L', bit image 960 dots/line
FC3928 6006             bra      $FC3930
```

```
FC392A 2EBC00FD1BD1          move.l  #$FD1BD1,(A7)     ESC 'Y', bit image 1280 dots/line
FC3930 61000772              bsr     $FC40A4           Send string to printer
FC3934 4A40                  tst.w   D0                Output OK?
FC3936 670E                  beq     $FC3946           Yes
FC3938 33FCFFFF000004EE      move.w  #-1,$4EE          Clear _dumpflg
FC3940 70FF                  moveq.l #-1,D0            Flag for error
FC3942 6000070A              bra     $FC404E           Terminate

FC3946 103900004E16          move.b  $4E16,D0          Number of points, low-byte
FC394C 4880                  ext.w   D0
FC394E 3E80                  move.w  D0,(A7)
FC3950 61000706              bsr     $FC4058           Output character
FC3954 4A40                  tst.w   D0                Output OK?
FC3956 670E                  beq     $FC3966           Yes
FC3958 33FCFFFF000004EE      move.w  #-1,$4EE          Clear _dumpflg
FC3960 70FF                  moveq.l #-1,D0            Flag for error
FC3962 600006EA              bra     $FC404E           Terminate

FC3966 103900004E18          move.b  $4E18,D0          Number of points, high-byte
FC396C 4880                  ext.w   D0
FC396E 3E80                  move.w  D0,(A7)
FC3970 610006E6              bsr     $FC4058           Output character
FC3974 4A40                  tst.w   D0                Output OK?
FC3976 670E                  beq     $FC3986           Yes
FC3978 33FCFFFF000004EE      move.w  #-1,$4EE          Clear _dumpflg
FC3980 70FF                  moveq.l #-1,D0            Flag for error
FC3982 600006CA              bra     $FC404E           Terminate

FC3986 13FC000100006000      move.b  #1,$6000
FC398E 23F90000564800005FEA  move.l  $5648,$5FEA
FC3998 33F90000574C00006028  move.w  $574C,$6028
```

```
FC39A2 4279000016A6         clr.w    $16A6
FC39A8 600004B0             bra      $FC3E5A

FC39AC 4247                 clr.w    D7
FC39AE 600C                 bra      $FC39BC

FC39B0 3047                 move.w   D7,A0
FC39B2 D1FC00005784         add.l    #$5784,A0
FC39B8 4210                 clr.b    (A0)
FC39BA 5247                 addq.w   #1,D7
FC39BC BE7C0008             cmp.w    #8,D7
FC39C0 6DEE                 blt      $FC39B0
FC39C2 4247                 clr.w    D7
FC39C4 601E                 bra      $FC39E4

FC39C6 3047                 move.w   D7,A0
FC39C8 D1C8                 add.l    A0,A0
FC39CA D1FC00004E1A         add.l    #$4E1A,A0
FC39D0 30BC0007             move.w   #7,(A0)
FC39D4 3047                 move.w   D7,A0
FC39D6 D1C8                 add.l    A0,A0
FC39D8 D1FC00005FEE         add.l    #$5FEE,A0
FC39DE 30BC0008             move.w   #8,(A0)
FC39E2 5247                 addq.w   #1,D7
FC39E4 BE7C0004             cmp.w    #4,D7
FC39E8 6DDC                 blt      $FC39C6
FC39EA 4240                 clr.w    D0
FC39EC 3039000029C6         move.w   $29C6,D0              p_height
FC39F2 9079000016A8         sub.w    $16A8,D0
FC39F8 4840                 swap     D0
FC39FA 4240                 clr.w    D0
FC39FC 4840                 swap     D0
```

```
FC39FE 80F900005FF8         divu.w   $5FF8,D0
FC3A04 6708                 beq      $FC3A0E
FC3A06 303900005FF8         move.w   $5FF8,D0
FC3A0C 600E                 bra      $FC3A1C

FC3A0E 4240                 clr.w    D0
FC3A10 3039000029C6         move.w   $29C6,D0               p_height
FC3A16 9079000016A8         sub.w    $16A8,D0
FC3A1C 33C000005FE0         move.w   D0,$5FE0
FC3A22 4240                 clr.w    D0
FC3A24 3039000029C6         move.w   $29C6,D0               p_height
FC3A2A 9079000016A8         sub.w    $16A8,D0
FC3A30 4840                 swap     D0
FC3A32 4240                 clr.w    D0
FC3A34 4840                 swap     D0
FC3A36 80F900005FF8         divu.w   $5FF8,D0
FC3A3C 670C                 beq      $FC3A4A
FC3A3E 33F900005FF800005FE0 move.w   $5FF8,$5FE0
FC3A48 601A                 bra      $FC3A64

FC3A4A 4240                 clr.w    D0
FC3A4C 3039000029C6         move.w   $29C6,D0               p_height
FC3A52 9079000016A8         sub.w    $16A8,D0
FC3A58 33C000005FE0         move.w   D0,$5FE0
FC3A5E 4239000060A0         clr.b    $60A0
FC3A64 23F900005FEA000058EC move.l   $5FEA,$58EC
FC3A6E 4247                 clr.w    D7
FC3A70 6000011C             bra      $FC3B8E

FC3A74 427900006030         clr.w    $6030
FC3A7A 33FC000100006024     move.w   #1,$6024
FC3A82 23F9000058EC0000574E move.l   $58EC,$574E
```

```
FC3A8C 4246                clr.w    D6
FC3A8E 6030                bra      $FC3AC0

FC3A90 20790000574E        move.l   $574E,A0
FC3A96 3010                move.w   (A0),D0
FC3A98 720F                moveq.l  #15,D1
FC3A9A 927900006028        sub.w    $6028,D1
FC3AA0 E260                asr.w    D1,D0
FC3AA2 C07C0001            and.w    #1,D0
FC3AA6 C1F900006024        muls.w   $6024,D0
FC3AAC D17900006030        add.w    D0,$6030
FC3AB2 54B90000574E        addq.l   #2,$574E
FC3AB8 E1F900006024        asl.w    $6024
FC3ABE 5246                addq.w   #1,D6
FC3AC0 BC79000056F8        cmp.w    $56F8,D6
FC3AC6 6DC8                blt      $FC3A90
FC3AC8 4A3900005FE6        tst.b    $5FE6               High resolution ?
FC3ACE 672C                beq      $FC3AFC             No
FC3AD0 303900006030        move.w   $6030,D0
FC3AD6 32390000608C        move.w   $608C,D1
FC3ADC B340                eor.w    D1,D0
FC3ADE 660C                bne      $FC3AEC
FC3AE0 2079000029D8        move.l   $29D8,A0            p_masks, address of half-tone mask
FC3AE6 1010                move.b   (A0),D0
FC3AE8 4880                ext.w    D0
FC3AEA 6002                bra      $FC3AEE

FC3AEC 4240                clr.w    D0
FC3AEE 3247                move.w   D7,A1
FC3AF0 D3FC00005784        add.l    #$5784,A1
FC3AF6 1280                move.b   D0,(A1)
FC3AF8 60000082            bra      $FC3B7C
```

```
FC3AFC 3047                   move.w  D7,A0
FC3AFE D0C8                   add.w   A0,A0
FC3B00 D1FC00005784           add.l   #$5784,A0
FC3B06 327900006030           move.w  $6030,A1
FC3B0C D3C9                   add.l   A1,A1
FC3B0E D3FC00006002           add.l   #$6002,A1
FC3B14 3251                   move.w  (A1),A1
FC3B16 D2C9                   add.w   A1,A1
FC3B18 D3F9000029D8           add.l   $29D8,A1           plus p_masks
FC3B1E 1091                   move.b  (A1),(A0)
FC3B20 3047                   move.w  D7,A0
FC3B22 D0C8                   add.w   A0,A0
FC3B24 D1FC00005784           add.l   #$5784,A0
FC3B2A 327900006030           move.w  $6030,A1
FC3B30 D3C9                   add.l   A1,A1
FC3B32 D3FC00006002           add.l   #$6002,A1
FC3B38 3251                   move.w  (A1),A1
FC3B3A D2C9                   add.w   A1,A1
FC3B3C D3F9000029D8           add.l   $29D8,A1           plus p_masks
FC3B42 116900010001           move.b  1(A1),1(A0)
FC3B48 3047                   move.w  D7,A0
FC3B4A D1C8                   add.l   A0,A0
FC3B4C D1FC00004E1A           add.l   #$4E1A,A0
FC3B52 327900006030           move.w  $6030,A1
FC3B58 D3C9                   add.l   A1,A1
FC3B5A D3FC00005628           add.l   #$5628,A1
FC3B60 3091                   move.w  (A1),(A0)
FC3B62 3047                   move.w  D7,A0
FC3B64 D1C8                   add.l   A0,A0
FC3B66 D1FC00005FEE           add.l   #$5FEE,A0
FC3B6C 327900006030           move.w  $6030,A1
FC3B72 D3C9                   add.l   A1,A1
```

```
FC3B74 D3FC00005760        add.l    #$5760,A1
FC3B7A 3091                move.w   (A1),(A0)
FC3B7C 303900005626        move.w   $5626,D0
FC3B82 E340                asl.w    #1,D0
FC3B84 48C0                ext.l    D0
FC3B86 D1B9000058EC        add.l    D0,$58EC
FC3B8C 5247                addq.w   #1,D7
FC3B8E BE7900005FE0        cmp.w    $5FE0,D7
FC3B94 6D00FEDE            blt      $FC3A74
FC3B98 4A390000575E        tst.b    $575E               ATARI color dot-matrix printer?
FC3B9E 670001BE            beq      $FC3D5E             No
FC3BA2 4A3900005FE6        tst.b    $5FE6               High resolution ?
FC3BA8 660001B4            bne      $FC3D5E             Yes
FC3BAC 4247                clr.w    D7
FC3BAE 600001A4            bra      $FC3D54

FC3BB2 423900005FF6        clr.b    $5FF6
FC3BB8 4A79000060A2        tst.w    $60A2
FC3BBE 6626                bne      $FC3BE6
FC3BC0 3047                move.w   D7,A0
FC3BC2 D1C8                add.l    A0,A0
FC3BC4 227C00004E1A        move.l   #$4E1A,A1
FC3BCA 30309800            move.w   0(A0,A1.l),D0
FC3BCE 48C0                ext.l    D0
FC3BD0 81FC0002            divs.w   #2,D0
FC3BD4 4840                swap     D0
FC3BD6 4A40                tst.w    D0
FC3BD8 6708                beq      $FC3BE2
FC3BDA 13FC000100005FF6    move.b   #1,$5FF6
FC3BE2 600000F0            bra      $FC3CD4

FC3BE6 0C790001000060A2    cmp.w    #1,$60A2
```

```
FC3BEE 6600008C          bne      $FC3C7C
FC3BF2 3047              move.w   D7,A0
FC3BF4 D1C8              add.l    A0,A0
FC3BF6 D1FC00004E1A      add.l    #$4E1A,A0
FC3BFC 0C500006          cmp.w    #6,(A0)
FC3C00 6630              bne      $FC3C32
FC3C02 3047              move.w   D7,A0
FC3C04 D1C8              add.l    A0,A0
FC3C06 D1FC00005FEE      add.l    #$5FEE,A0
FC3C0C 0C500008          cmp.w    #8,(A0)
FC3C10 6C20              bge      $FC3C32
FC3C12 3047              move.w   D7,A0
FC3C14 D0C8              add.w    A0,A0
FC3C16 D1FC00005784      add.l    #$5784,A0
FC3C1C 02100001          and.b    #1,(A0)
FC3C20 3047              move.w   D7,A0
FC3C22 D0C8              add.w    A0,A0
FC3C24 D1FC00005784      add.l    #$5784,A0
FC3C2A 022800040001      and.b    #4,1(A0)
FC3C30 6048              bra      $FC3C7A

FC3C32 3047              move.w   D7,A0
FC3C34 D1C8              add.l    A0,A0
FC3C36 D1FC00004E1A      add.l    #$4E1A,A0
FC3C3C 0C500002          cmp.w    #2,(A0)
FC3C40 6730              beq      $FC3C72
FC3C42 3047              move.w   D7,A0
FC3C44 D1C8              add.l    A0,A0
FC3C46 D1FC00004E1A      add.l    #$4E1A,A0
FC3C4C 0C500003          cmp.w    #3,(A0)
FC3C50 6720              beq      $FC3C72
FC3C52 3047              move.w   D7,A0
```

```
FC3C54 D1C8              add.l   A0,A0
FC3C56 D1FC00004E1A      add.l   #$4E1A,A0
FC3C5C 0C500006          cmp.w   #6,(A0)
FC3C60 6710              beq     $FC3C72
FC3C62 3047              move.w  D7,A0
FC3C64 D1C8              add.l   A0,A0
FC3C66 D1FC00004E1A      add.l   #$4E1A,A0
FC3C6C 0C500007          cmp.w   #7,(A0)
FC3C70 6608              bne     $FC3C7A
FC3C72 13FC000100005FF6  move.b  #1,$5FF6
FC3C7A 6058              bra     $FC3CD4

FC3C7C 3047              move.w  D7,A0
FC3C7E D1C8              add.l   A0,A0
FC3C80 D1FC00004E1A      add.l   #$4E1A,A0
FC3C86 0C500006          cmp.w   #6,(A0)
FC3C8A 6630              bne     $FC3CBC
FC3C8C 3047              move.w  D7,A0
FC3C8E D1C8              add.l   A0,A0
FC3C90 D1FC00005FEE      add.l   #$5FEE,A0
FC3C96 0C500008          cmp.w   #8,(A0)
FC3C9A 6C20              bge     $FC3CBC
FC3C9C 3047              move.w  D7,A0
FC3C9E D0C8              add.w   A0,A0
FC3CA0 D1FC00005784      add.l   #$5784,A0
FC3CA6 02100004          and.b   #4,(A0)
FC3CAA 3047              move.w  D7,A0
FC3CAC D0C8              add.w   A0,A0
FC3CAE D1FC00005784      add.l   #$5784,A0
FC3CB4 022800010001      and.b   #1,1(A0)
FC3CBA 6018              bra     $FC3CD4
```

```
FC3CBC 3047                 move.w  D7,A0
FC3CBE D1C8                 add.l   A0,A0
FC3CC0 D1FC00004E1A         add.l   #$4E1A,A0
FC3CC6 0C500003             cmp.w   #3,(A0)
FC3CCA 6F08                 ble     $FC3CD4
FC3CCC 13FC000100005FF6     move.b  #1,$5FF6
FC3CD4 4A3900005FF6         tst.b   $5FF6
FC3CDA 671A                 beq     $FC3CF6
FC3CDC 3047                 move.w  D7,A0
FC3CDE D0C8                 add.w   A0,A0
FC3CE0 D1FC00005784         add.l   #$5784,A0
FC3CE6 4210                 clr.b   (A0)
FC3CE8 3047                 move.w  D7,A0
FC3CEA D0C8                 add.w   A0,A0
FC3CEC D1FC00005784         add.l   #$5784,A0
FC3CF2 42280001             clr.b   1(A0)
FC3CF6 2079000029D8         move.l  $29D8,A0            p_masks
FC3CFC 3247                 move.w  D7,A1
FC3CFE D3C9                 add.l   A1,A1
FC3D00 D3FC00005FEE         add.l   #$5FEE,A1
FC3D06 3251                 move.w  (A1),A1
FC3D08 D2C9                 add.w   A1,A1
FC3D0A 10309000             move.b  0(A0,A1.w),D0
FC3D0E 4880                 ext.w   D0
FC3D10 3F00                 move.w  D0,-(A7)
FC3D12 3047                 move.w  D7,A0
FC3D14 D0C8                 add.w   A0,A0
FC3D16 D1FC00005784         add.l   #$5784,A0
FC3D1C 1010                 move.b  (A0),D0
FC3D1E 805F                 or.w    (A7)+,D0
FC3D20 1080                 move.b  D0,(A0)
FC3D22 2079000029D8         move.l  $29D8,A0            p_masks
```

```
FC3D28 3247              move.w   D7,A1
FC3D2A D3C9              add.l    A1,A1
FC3D2C D3FC00005FEE      add.l    #$5FEE,A1
FC3D32 3251              move.w   (A1),A1
FC3D34 D2C9              add.w    A1,A1
FC3D36 10309001          move.b   1(A0,A1.w),D0
FC3D3A 4880              ext.w    D0
FC3D3C 3F00              move.w   D0,-(A7)
FC3D3E 3047              move.w   D7,A0
FC3D40 D0C8              add.w    A0,A0
FC3D42 D1FC00005784      add.l    #$5784,A0
FC3D48 10280001          move.b   1(A0),D0
FC3D4C 805F              or.w     (A7)+,D0
FC3D4E 11400001          move.b   D0,1(A0)
FC3D52 5247              addq.w   #1,D7
FC3D54 BE7900005FE0      cmp.w    $5FE0,D7
FC3D5A 6D00FE56          blt      $FC3BB2
FC3D5E 7E04              moveq.l  #4,D7
FC3D60 6000008E          bra      $FC3DF0

FC3D64 42390000414C      clr.b    $414C
FC3D6A 33FC008000006026  move.w   #$80,$6026
FC3D72 4246              clr.w    D6
FC3D74 603E              bra      $FC3DB4

FC3D76 207C00005784      move.l   #$5784,A0
FC3D7C 10306000          move.b   0(A0,D6.w),D0
FC3D80 4880              ext.w    D0
FC3D82 7207              moveq.l  #7,D1
FC3D84 9247              sub.w    D7,D1
FC3D86 E260              asr.w    D1,D0
FC3D88 C07C0001          and.w    #1,D0
```

```
FC3D8C C1F900006026          muls.w   $6026,D0
FC3D92 12390000414C          move.b   $414C,D1
FC3D98 D200                  add.b    D0,D1
FC3D9A 13C10000414C          move.b   D1,$414C
FC3DA0 303900006026          move.w   $6026,D0
FC3DA6 48C0                  ext.l    D0
FC3DA8 81FC0002              divs.w   #2,D0
FC3DAC 33C000006026          move.w   D0,$6026
FC3DB2 5246                  addq.w   #1,D6
FC3DB4 BC7C0008              cmp.w    #8,D6
FC3DB8 6DBC                  blt      $FC3D76
FC3DBA 10390000414C          move.b   $414C,D0
FC3DC0 4880                  ext.w    D0
FC3DC2 3E80                  move.w   D0,(A7)
FC3DC4 61000292              bsr      $FC4058         Output character
FC3DC8 4A40                  tst.w    D0              Output OK?
FC3DCA 670E                  beq      $FC3DDA         Yes
FC3DCC 33FCFFFF000004EE      move.w   #-1,$4EE        Clear _dumpflg
FC3DD4 70FF                  moveq.l  #-1,D0          Flag for error
FC3DD6 60000276              bra      $FC404E         Terminate

FC3DDA 4A3900006000          tst.b    $6000
FC3DE0 6704                  beq      $FC3DE6
FC3DE2 4240                  clr.w    D0
FC3DE4 6002                  bra      $FC3DE8

FC3DE6 7001                  moveq.l  #1,D0
FC3DE8 13C000006000          move.b   D0,$6000
FC3DEE 5247                  addq.w   #1,D7
FC3DF0 303900006022          move.w   $6022,D0
FC3DF6 5840                  addq.w   #4,D0
FC3DF8 BE40                  cmp.w    D0,D7
```

```
FC3DFA 6D00FF68          blt      $FC3D64
FC3DFE 4A3900005780      tst.b    $5780           Epson B/W dot-matrix printer?
FC3E04 6728              beq      $FC3E2E         No
FC3E06 4A3900006000      tst.b    $6000
FC3E0C 6720              beq      $FC3E2E
FC3E0E 10390000414C      move.b   $414C,D0
FC3E14 4880              ext.w    D0
FC3E16 3E80              move.w   D0,(A7)
FC3E18 6100023E          bsr      $FC4058         Output character
FC3E1C 4A40              tst.w    D0              Output OK?
FC3E1E 670E              beq      $FC3E2E         Yes
FC3E20 33FCFFFF000004EE  move.w   #-1,$4EE        Clear _dumpflg
FC3E28 70FF              moveq.l  #-1,D0          Flag for error
FC3E2A 60000222          bra      $FC404E         Terminate

FC3E2E 527900006028      addq.w   #1,$6028
FC3E34 0C79000F00006028  cmp.w    #15,$6028
FC3E3C 6F16              ble      $FC3E54
FC3E3E 3039000056F8      move.w   $56F8,D0
FC3E44 E340              asl.w    #1,D0
FC3E46 48C0              ext.l    D0
FC3E48 D1B900005FEA      add.l    D0,$5FEA
FC3E4E 427900006028      clr.w    $6028
FC3E54 5279000016A6      addq.w   #1,$16A6
FC3E5A 3039000016A6      move.w   $16A6,D0
FC3E60 B07900004DBC      cmp.w    $4DBC,D0
FC3E66 6D00FB44          blt      $FC39AC
FC3E6A 3EBC000D          move.w   #$D,(A7)        Carriage Return
FC3E6E 610001E8          bsr      $FC4058         Output character
FC3E72 4A40              tst.w    D0              Output OK?
FC3E74 670E              beq      $FC3E84         Yes
FC3E76 33FCFFFF000004EE  move.w   #-1,$4EE        Clear _dumpflg
```

```
FC3E7E 70FF              moveq.l #-1,D0           Flag for error
FC3E80 600001CC          bra     $FC404E          Terminate

FC3E84 5279000060A2      addq.w  #1,$60A2
FC3E8A 4A390000575E      tst.b   $575E            ATARI color dot-matrix printer?
FC3E90 670C              beq     $FC3E9E          No
FC3E92 4A3900005FE6      tst.b   $5FE6            High resolution ?
FC3E98 6604              bne     $FC3E9E          Yes
FC3E9A 7003              moveq.l #3,D0
FC3E9C 6002              bra     $FC3EA0

FC3E9E 7001              moveq.l #1,D0
FC3EA0 B079000060A2      cmp.w   $60A2,D0
FC3EA6 6E00F9F4          bgt     $FC389C
FC3EAA 2EBC00FD1BD5      move.l  #$FD1BD5,(A7)    ESC '3', 1, 1/216" line spacing
FC3EB0 610001F2          bsr     $FC40A4          Send string to printer
FC3EB4 4A40              tst.w   D0               Output OK?
FC3EB6 670E              beq     $FC3EC6          Yes
FC3EB8 33FCFFFF000004EE  move.w  #-1,$4EE         Clear _dumpflg
FC3EC0 70FF              moveq.l #-1,D0           Flag for error
FC3EC2 6000018A          bra     $FC404E          Terminate

FC3EC6 3EBC000A          move.w  #$A,(A7)         Linefeed
FC3ECA 6100018C          bsr     $FC4058          Output character
FC3ECE 4A40              tst.w   D0               Output OK?
FC3ED0 670E              beq     $FC3EE0          Yes
FC3ED2 33FCFFFF000004EE  move.w  #-1,$4EE         Clear _dumpflg
FC3EDA 70FF              moveq.l #-1,D0           Flag for error
FC3EDC 60000170          bra     $FC404E          Terminate

FC3EE0 527900005782      addq.w  #1,$5782
FC3EE6 4A3900005FFE      tst.b   $5FFE            Quality mode?
```

```
FC3EEC 6704           beq      $FC3EF2            Yes
FC3EEE 7001           moveq.l  #1,D0
FC3EF0 6002           bra      $FC3EF4

FC3EF2 7002           moveq.l  #2,D0
FC3EF4 B07900005782   cmp.w    $5782,D0
FC3EFA 6E00F996       bgt      $FC3892
FC3EFE 4A3900005FFE   tst.b    $5FFE              Quality mode?
FC3F04 674E           beq      $FC3F54            Yes
FC3F06 4247           clr.w    D7
FC3F08 6038           bra      $FC3F42

FC3F0A 2EBC00FD1BDA   move.l   #$FD1BDA,(A7)      ESC '3', 1, 1/216" line spacing
FC3F10 61000192       bsr      $FC40A4            Send string to printer
FC3F14 4A40           tst.w    D0                 Output OK?
FC3F16 670E           beq      $FC3F26            Yes
FC3F18 33FCFFFF000004EE move.w #-1,$4EE           Clear _dumpflg
FC3F20 70FF           moveq.l  #-1,D0             Flag for error
FC3F22 6000012A       bra      $FC404E            Terminate

FC3F26 3EBC000A       move.w   #$A,(A7)           Linefeed
FC3F2A 6100012C       bsr      $FC4058            Output character
FC3F2E 4A40           tst.w    D0                 Output OK?
FC3F30 670E           beq      $FC3F40            Yes
FC3F32 33FCFFFF000004EE move.w #-1,$4EE           Clear _dumpflg
FC3F3A 70FF           moveq.l  #-1,D0             Flag for error
FC3F3C 60000110       bra      $FC404E            Terminate

FC3F40 5247           addq.w   #1,D7
FC3F42 4A3900005780   tst.b    $5780              Epson B/W dot-matrix printer?
FC3F48 6704           beq      $FC3F4E            No
```

```
FC3F4A 7002              moveq.l #2,D0
FC3F4C 6002              bra     $FC3F50

FC3F4E 7001              moveq.l #1,D0
FC3F50 BE40              cmp.w   D0,D7
FC3F52 6DB6              blt     $FC3F0A
FC3F54 4A39000060A0      tst.b   $60A0
FC3F5A 6738              beq     $FC3F94
FC3F5C 2EBC00FD1BDF      move.l  #$FD1BDF,(A7)     ESC '1', 7/72" line spacing
FC3F62 61000140          bsr     $FC40A4           Send string to printer
FC3F66 4A40              tst.w   D0                Output OK?
FC3F68 670E              beq     $FC3F78           Yes
FC3F6A 33FCFFFF000004EE  move.w  #-1,$4EE          Clear _dumpflg
FC3F72 70FF              moveq.l #-1,D0            Flag for error
FC3F74 600000D8          bra     $FC404E           Terminate

FC3F78 3EBC000A          move.w  #$A,(A7)          Linefeed
FC3F7C 610000DA          bsr     $FC4058           Output character
FC3F80 4A40              tst.w   D0                Output OK?
FC3F82 670E              beq     $FC3F92           Yes
FC3F84 33FCFFFF000004EE  move.w  #-1,$4EE          Clear _dumpflg
FC3F8C 70FF              moveq.l #-1,D0            Flag for error
FC3F8E 600000BE          bra     $FC404E           Terminate

FC3F92 6060              bra     $FC3FF4

FC3F94 4247              clr.w   D7
FC3F96 6038              bra     $FC3FD0

FC3F98 2EBC00FD1BE3      move.l  #$FD1BE3,(A7)     ESC '3', 1, 1/216" line spacing
FC3F9E 61000104          bsr     $FC40A4           Send string to printer
```

```
FC3FA2 4A40              tst.w    D0           Output OK?
FC3FA4 670E              beq      $FC3FB4      Yes
FC3FA6 33FCFFFF000004EE  move.w   #-1,$4EE     Clear _dumpflg
FC3FAE 70FF              moveq.l  #-1,D0       Flag for error
FC3FB0 6000009C          bra      $FC404E      Terminate

FC3FB4 3EBC000A          move.w   #$A,(A7)     Linefeed
FC3FB8 6100009E          bsr      $FC4058      Output character
FC3FBC 4A40              tst.w    D0           Output OK?
FC3FBE 670E              beq      $FC3FCE      Yes
FC3FC0 33FCFFFF000004EE  move.w   #-1,$4EE     Clear _dumpflg
FC3FC8 70FF              moveq.l  #-1,D0       Flag for error
FC3FCA 60000082          bra      $FC404E      Terminate

FC3FCE 5247              addq.w   #1,D7
FC3FD0 4A3900005780      tst.b    $5780        Epson B/W dot-matrix printer?
FC3FD6 670E              beq      $FC3FE6      No
FC3FD8 303900005FE0      move.w   $5FE0,D0
FC3FDE C1FC0006          muls.w   #6,D0
FC3FE2 5740              subq.w   #3,D0
FC3FE4 600A              bra      $FC3FF0

FC3FE6 303900005FE0      move.w   $5FE0,D0
FC3FEC E540              asl.w    #2,D0
FC3FEE 5540              subq.w   #2,D0
FC3FF0 BE40              cmp.w    D0,D7
FC3FF2 6DA4              blt      $FC3F98
FC3FF4 303900004E10      move.w   $4E10,D0
FC3FFA E340              asl.w    #1,D0
FC3FFC 48C0              ext.l    D0
FC3FFE D1B900005648      add.l    D0,$5648
FC4004 303900005FF8      move.w   $5FF8,D0
```

```
FC400A D179000016A8         add.w   D0,$16A8
FC4010 4240                 clr.w   D0
FC4012 3039000029C6         move.w  $29C6,D0              p_height
FC4018 B079000016A8         cmp.w   $16A8,D0
FC401E 6200F67C             bhi     $FC369C
FC4022 2EBC00FD1BE8         move.l  #$FD1BE8,(A7)         ESC '2', 1/6" line spacing
FC4028 6100007A             bsr     $FC40A4               Send string to printer
FC402C 4A390000575E         tst.b   $575E                 ATARI color dot-matrix printer?
FC4032 6710                 beq     $FC4044               No
FC4034 4A3900005FE6         tst.b   $5FE6                 High resolution ?
FC403A 6608                 bne     $FC4044               Yes
FC403C 2EBC00FD1BEC         move.l  #$FD1BEC,(A7)         ESC 'X', 0
FC4042 6160                 bsr     $FC40A4               Send string to printer
FC4044 33FCFFFF000004EE     move.w  #-1,$4EE              Clear _dumpflg
FC404C 4240                 clr.w   D0                    OK
FC404E 4A9F                 tst.l   (A7)+
FC4050 4CDF30C0             movem.l (A7)+,D6-D7/A4-A5     Restore registers
FC4054 4E5E                 unlk    A6
FC4056 4E75                 rts

*************************************************         Output character to printer
FC4058 4E56FFFC             link    A6,#-4
FC405C 4A39000029BC         tst.b   $29BC                 Printer port
FC4062 6722                 beq     $FC4086               RS 232 ?
FC4064 102E0009             move.b  9(A6),D0              Get character
FC4068 4880                 ext.w   D0
FC406A 3E80                 move.w  D0,(A7)               on the stack
FC406C 102E0009             move.b  9(A6),D0
FC4070 4880                 ext.w   D0
FC4072 3F00                 move.w  D0,-(A7)              (again ?)
FC4074 4EB900FC40E4         jsr     $FC40E4               Output character to printer
FC407A 548F                 addq.l  #2,A7
```

```
FC407C 4A40            tst.w    D0            OK ?
FC407E 6604            bne      $FC4084       Yes
FC4080 70FF            moveq.l  #-1,D0        Flag for error
FC4082 601C            bra      $FC40A0       Terminate

FC4084 6018            bra      $FC409E       OK
FC4086 102E0009        move.b   9(A6),D0      Get character
FC408A 4880            ext.w    D0
FC408C 3E80            move.w   D0,(A7)       on stack
FC408E 102E0009        move.b   9(A6),D0
FC4092 4880            ext.w    D0
FC4094 3F00            move.w   D0,-(A7)      (again ?)
FC4096 4EB900FC4112    jsr      $FC4112       RS 232 output
FC409C 548F            addq.l   #2,A7
FC409E 4240            clr.w    D0            OK
FC40A0 4E5E            unlk     A6
FC40A2 4E75            rts

***************************************************** Send string to printer
FC40A4 4E56FFFC        link     A6,#-4
FC40A8 6018            bra      $FC40C2

FC40AA 206E0008        move.l   8(A6),A0      String address
FC40AE 1010            move.b   (A0),D0       Character of the string
FC40B0 4880            ext.w    D0
FC40B2 3E80            move.w   D0,(A7)       on stack
FC40B4 61A2            bsr      $FC4058       Output character
FC40B6 52AE0008        addq.l   #1,8(A6)      Pointer to next character
FC40BA 4A40            tst.w    D0            Output OK?
FC40BC 6704            beq      $FC40C2       Yes
FC40BE 70FF            moveq.l  #-1,D0        Flag for error
FC40C0 600C            bra      $FC40CE
```

```
FC40C2 206E0008        move.l  8(A6),A0            String address
FC40C6 0C1000FF        cmp.b   #$FF,(A0)           End criterium reached?
FC40CA 66DE            bne     $FC40AA             No
FC40CC 4240            clr.w   D0                  OK
FC40CE 4E5E            unlk    A6
FC40D0 4E75            rts

*********************************************      Get printer status
FC40D2 48E71F1E        movem.l D3-D7/A3-A6,-(A7)   Save registers
FC40D6 9BCD            sub.l   A5,A5               Clear A5
FC40D8 206D0506        move.l  $506(A5),A0         prt_stat
FC40DC 4E90            jsr     (A0)                Jump via vector
FC40DE 4CDF78F8        movem.l (A7)+,D3-D7/A3-A6   Restore registers
FC40E2 4E75            rts

*********************************************      Printer output
FC40E4 302F0006        move.w  6(A7),D0            Character to output
FC40E8 48E71F1E        movem.l D3-D7/A3-A6,-(A7)   Save registers
FC40EC 3F00            move.w  D0,-(A7)            Character on stack
FC40EE 3F00            move.w  D0,-(A7)            (again ?)
FC40F0 9BCD            sub.l   A5,A5               Clear A5
FC40F2 206D050A        move.l  $50A(A5),A0         prt_vec
FC40F6 4E90            jsr     (A0)                Jump via vector
FC40F8 584F            addq.w  #4,A7               Correct stack pointer
FC40FA 4CDF78F8        movem.l (A7)+,D3-D7/A3-A6   Restore registers
FC40FE 4E75            rts

*********************************************      RS 232 output status
FC4100 48E71F1E        movem.l D3-D7/A3-A6,-(A7)   Save regisers
FC4104 9BCD            sub.l   A5,A5               Clear A5
FC4106 206D050E        move.l  $50E(A5),A0         aux_stat
FC410A 4E90            jsr     (A0)                Jump via vector
```

```
FC410C 4CDF78F8          movem.l (A7)+,D3-D7/A3-A6     Restore registers
FC4110 4E75              rts

*******************************************************  RS 232 output
FC4112 302F0006          move.w  6(A7),D0               Character to output
FC4116 48E71F1E          movem.l D3-D7/A3-A6,-(A7)      Save registers
FC411A 3F00              move.w  D0,-(A7)               Character on stack
FC411C 3F00              move.w  D0,-(A7)               (again ?)
FC411E 9BCD              sub.l   A5,A5                  Clear A5
FC4120 206D0512          move.l  $512(A5),A0            aux_vec
FC4124 4E90              jsr     (A0)                   Jump via vector
FC4126 584F              addq.w  #4,A7                  Correct stack pointer
FC4128 4CDF78F8          movem.l (A7)+,D3-D7/A3-A6      Restore registers
FC412C 4E75              rts

*******************************************************  VDI ESCAPE functions
FC412E 20790000293E      move.l  $293E,A0               Address of the CONTRL array
FC4134 3028000A          move.w  10(A0),D0              Function number
FC4138 B07C0013          cmp.w   #$13,D0                Greater than 19 ?
FC413C 6236              bhi     $FC4174                Yes
FC413E E340              asl.w   #1,D0
FC4140 307B000A          move.w  $FC414C(PC,D0.w),A0    Get relative address from the table
FC4144 D1FC00FC4348      add.l   #$FC4348,A0            Add base address
FC414A 4ED0              jmp     (A0)                   Execute routine

*******************************************************  Address of the VDI escape functions
FC414C 0000              dc.w    $FC4348-$FC4348        0, rts
FC414E FFD8              dc.w    $FC4320-$FC4348        1, Inquire addressable alpha character cells
FC4150 0012              dc.w    $FC435A-$FC4348        2, Exit alpha mode
FC4152 000C              dc.w    $FC4354-$FC4348        3, Enter alpha mode
FC4154 001A              dc.w    $FC4362-$FC4348        4, Alpha cursor up
FC4156 002E              dc.w    $FC4376-$FC4348        5, Alpha cursor down
```

```
FC4158 0048          dc.w    $FC4390-$FC4348     6, Alpha cursor right
FC415A 0062          dc.w    $FC43AA-$FC4348     7, Alpha cursor left
FC415C 0076          dc.w    $FC436E-$FC4348     8, Home alpha cursor
FC415E 007E          dc.w    $FC43C6-$FC4348     9, Erase to end of alpha screen
FC4160 00AA          dc.w    $FC43F2-$FC4348     10, Erase to end of alpha text line
FC4162 0114          dc.w    $FC445C-$FC4348     11, Direct alpha cursor address
FC4164 0128          dc.w    $FC4470-$FC4348     12, Output cursor addressable alpha text
FC4166 014E          dc.w    $FC4496-$FC4348     13, Reverse video on
FC4168 0158          dc.w    $FC44A0-$FC4348     14, Reverse video off
FC416A 0162          dc.w    $FC44AA-$FC4348     15, Inquire current alpha cursor address
FC416C 018C          dc.w    $FC44D4-$FC4348     16, Inquire tablet status
FC416E 0002          dc.w    $FC434A-$FC4348     17, Hardcopy
FC4170 01A4          dc.w    $FC44EC-$FC4348     18, Place graphic cursor at location
FC4172 01B4          dc.w    $FC44FC-$FC4348     19, Remove last graphic cursor

*****************************************************
FC4174 B07C065       cmp.w   #$65,D0             VDI ESC 101 ?
FC4178 670A          beq     $FC4178             Yes
FC417A B07C0066      cmp.w   #$66,D0             VDI ESC 102 ?
FC417E 6700096A      beq     $FC4AEA             Yes, select font
FC4182 4E75          rts

*****************************************************  VDI ESC 101, character offset from screen start
FC4184 6100043C      bsr     $FC45C2             Cursor off
FC4188 207900002942  move.l  $2942,A0            Address of INTIN array
FC418E 3010          move.w  (A0),D0             INTIN[0], offset in raster lines
FC4190 C0F90000293C  mulu.w  $293C,D0            times bytes per screen line
FC4196 33C00000291C  move.w  D0,$291C            equals offset in bytes
FC419C 60000412      bra     $FC45B0             Turn cursor on again

*****************************************************  ascout
FC41A0 322F0006      move.w  6(A7),D1            Get character from stack
```

```
FC41A4 024100FF          and.w   #$FF,D1              Bits 0-7
FC41A8 600005D2          bra     $FC477C              Output character

*****************************************************  conout
FC41AC 322F0006          move.w  6(A7),D1             Character from stack
FC41B0 024100FF          and.w   #$FF,D1              Bits 0-7
FC41B4 2079000004A8      move.l  $4A8,A0              con_state vector
FC41BA 4ED0              jmp     (A0)                 Execute routine

*****************************************************  Standard conout
FC41BC B27C0020          cmp.w   #$20,D1              Control code ?
FC41C0 6C0005BA          bge     $FC477C              No, output character
FC41C4 B23C001B          cmp.b   #$1B,D1              ESC ?
FC41C8 660C              bne     $FC41D6              No, different control codes
FC41CA 23FC00FC4218000004A8 move.l #$FC4218,$4A8      con_state to ESC processing
FC41D4 4E75              rts

*****************************************************  Process CTRL codes
FC41D6 5F41              subq.w  #7,D1                Less than 7 ?
FC41D8 6B22              bmi     $FC41FC              ignore
FC41DA B27C0006          cmp.w   #6,D1                Greater than 13 ?
FC41DE 6E1C              bgt     $FC41FC              ignore
FC41E0 E349              lsl.w   #1,D1                as word index
FC41E2 307B100A          move.w  $FC41EE(PC,D1.w),A0  Get relative address from table
FC41E6 D1FC00FC41FE      add.l   #$FC41FE,A0          Add base address
FC41EC 4ED0              jmp     (A0)                 Execute routine

*****************************************************  Jump table for CTRL codes
FC41EE 0000              dc.w    $FC41FE-$FC41FE      7, BEL
FC41F0 01AC              dc.w    $FC43AA-$FC41FE      8, BS
FC41F2 0004              dc.w    $FC4202-$FC41FE      9, TAB
FC41F4 049E              dc.w    $FC469C-$FC41FE      10, LF
```

```
FC41F6 049E              dc.w    $FC469C-$FC41FE    11, VT
FC41F8 049E              dc.w    $FC469C-$FC41FE    12, FF
FC41FA 0492              dc.w    $FC4690-$FC41FE    13, CR

*****************************************************
FC41FC 4E75              rts                        rts for dummy routine

*****************************************************  BEL
FC41FE 6000DE1C          bra     $FC201C            Output sound

*****************************************************  TAB
FC4202 30390000291E      move.w  $291E,D0           Current cursor column
FC4208 0240FFF8          and.w   #$FFF8,D0          Convert to number divisable by 8
FC420C 5040              addq.w  #8,D0              plus 8
FC420E 323900002920      move.w  $2920,D1           Current cursor line
FC4214 60000764          bra     $FC497A            Reposition cursor

*****************************************************  Process character as ESC
FC4218 23FC00FC41BC000004A8 move.l  #$FC41BC,$4A8  con_state back to standard
FC4222 927C0041          sub.w   #$41,D1            minus 'A'
FC4226 6BD4              bmi     $FC41FC            less, ignore
FC4228 B27C000C          cmp.w   #$C,D1             'M'
FC422C 6F50              ble     $FC427E            To escape table for uppercase letters
FC422E B27C0018          cmp.w   #$18,D1            'Y' for set cursor?
FC4232 663C              bne     $FC4270            No, test for lowercase letters
FC4234 23FC00FC4240000004A8 move.l  #$FC4240,$4A8  con_state for ESC Y
FC423E 4E75              rts

*****************************************************  Process line under ESC Y
FC4240 927C0020          sub.w   #$20,D1            Subtract offset
FC4244 33C1000004AC      move.w  D1,$4AC            save_row, save line
```

```
FC424A 23FC00FC4256000004A8 move.l  #$FC4256,$4A8      con_state to column process
FC4254 4E75                 rts

*******************************************************  Process column under ESC Y
FC4256 927C0020             sub.w   #$20,D1            Subtract offset
FC425A 3001                 move.w  D1,D0              Column
FC425C 3239000004AC         move.w  $4AC,D1            save_row, line
FC4262 23FC00FC41BC000004A8 move.l  #$FC41BC,$4A8      con_state to standard
FC426C 6000070C             bra     $FC497A            Set cursor

*******************************************************  Test for ESC lowercase letters
FC4270 927C0021             sub.w   #$21,D1            Subtract offset
FC4274 6B86                 bmi     $FC41FC            less than 'b' ignore
FC4276 B27C0015             cmp.w   #$15,D1            'w'
FC427A 6F10                 ble     $FC428C            less than or equal, process sequence
FC427C 4E75                 rts

*******************************************************  ESC uppercase letters
FC427E E349                 lsl.w   #1,D1              Word access
FC4280 307B1058             move.w  $FC42DA(PC,D1.w),A0  Get relative address from table
FC4284 D1FC00FC41FC         add.l   #$FC41FC,A0        Add base address
FC428A 4ED0                 jmp     (A0)               Execute routine

*******************************************************  ESC lowercase letters
FC428C E349                 lsl.w   #1,D1              Word access
FC428E 307B1064             move.w  $FC42F4(PC,D1.w),A0  Get relative address from table
FC4292 D1FC00FC41FC         add.l   #$FC41FC,A0        Add base address
FC4298 4ED0                 jmp     (A0)               Execute routine

*******************************************************  ESC b, set type color
FC429A 23FC00FC42A6000004A8 move.l  #$FC42A6,$4A8      Set con_state
FC42A4 4E75                 rts
```

```
*****************************************************   Set type color
FC42A6 23FC00FC41BC000004A8 move.l  #$FC41BC,$4A8      con_state to standard
FC42B0 927C0020             sub.w   #$20,D1            Subtract offset
FC42B4 3001                 move.w  D1,D0
FC42B6 60000290             bra     $FC4548            Set type color

*****************************************************   ESC c, set background color
FC42BA 23FC00FC42C6000004A8 move.l  #$FC42C6,$4A8      Set con_state
FC42C4 4E75                 rts

*****************************************************   Set background color
FC42C6 23FC00FC41BC000004A8 move.l  #$FC41BC,$4A8      con_state to standard
FC42D0 927C0020             sub.w   #$20,D1            Subtract offset
FC42D4 3001                 move.w  D1,D0
FC42D6 6000027C             bra     $FC4554            Set background color

*****************************************************   Address table for ESC uppercase
FC42DA 0166                 dc.w    $FC4362-$FC41FC    ESC A
FC42DC 017A                 dc.w    $FC4376-$FC41FC    ESC B
FC42DE 0194                 dc.w    $FC4390-$FC41FC    ESC C
FC42E0 01AE                 dc.w    $FC43AA-$FC41FC    ESC D
FC42E2 0162                 dc.w    $FC435E-$FC41FC    ESC E
FC42E4 0000                 dc.w    $FC41FC-$FC41FC    ESC F, rts
FC42E6 0000                 dc.w    $FC41FC-$FC41FC    ESC G, rts
FC42E8 01C2                 dc.w    $FC436E-$FC41FC    ESC H
FC42EA 0306                 dc.w    $FC4502-$FC41FC    ESC I
FC42EC 01CA                 dc.w    $FC43C6-$FC41FC    ESC J
FC42EE 01F6                 dc.w    $FC43F2-$FC41FC    ESC K
FC42F0 0320                 dc.w    $FC451C-$FC41FC    ESC L
FC42F2 033C                 dc.w    $FC4538-$FC41FC    ESC M
```

```
*****************************************************     Address table for ESC lowercase
FC42F4 009E              dc.w    $FC429A-$FC41FC          ESC b
FC42F6 00BE              dc.w    $FC42BA-$FC41FC          ESC c
FC42F8 0364              dc.w    $FC4560-$FC41FC          ESC d
FC42FA 0380              dc.w    $FC457C-$FC41FC          ESC e
FC42FC 03C6              dc.w    $FC45C2-$FC41FC          ESC f
FC42FE 0000              dc.w    $FC41FC-$FC41FC          ESC g, rts
FC4300 0000              dc.w    $FC41FC-$FC41FC          ESC h, rts
FC4302 0000              dc.w    $FC41FC-$FC41FC          ESC i, rts
FC4304 03E6              dc.w    $FC45E2-$FC41FC          ESC j
FC4306 0402              dc.w    $FC45FE-$FC41FC          ESC k
FC4308 041C              dc.w    $FC4618-$FC41FC          ESC l
FC430A 0000              dc.w    $FC41FC-$FC41FC          ESC m, rts
FC430C 0000              dc.w    $FC41FC-$FC41FC          ESC n, rts
FC430E 043A              dc.w    $FC4636-$FC41FC          ESC o
FC4310 029A              dc.w    $FC4496-$FC41FC          ESC p
FC4312 02A4              dc.w    $FC44A0-$FC41FC          ESC q
FC4314 0000              dc.w    $FC41FC-$FC41FC          ESC r, rts
FC4316 0000              dc.w    $FC41FC-$FC41FC          ESC s, rts
FC4318 0000              dc.w    $FC41FC-$FC41FC          ESC t, rts
FC431A 0000              dc.w    $FC41FC-$FC41FC          ESC u, rts
FC431C 0480              dc.w    $FC467C-$FC41FC          ESC v
FC431E 048A              dc.w    $FC4686-$FC41FC          ESC w

*****************************************************     VDI ESC 1, get screen size
FC4320 20790000293E      lea     $293E,A0                 Address of CONTRL array
FC4326 317C00020008      move.w  #2,8(A0)                 2 result values
FC432C 20790000294A      move.l  $294A,A0                 Address of INTOUT array
FC4332 30390000290E      move.w  $290E,D0                 Maximum cursor column
FC4338 5240              addq.w  #1,D0                    plus 1 equals number of columns
FC433A 31400002          move.w  D0,2(A0)                 as INTOUT[1]
FC433E 303900002910      move.w  $2910,D0                 Maximum cursor line
```

```
FC4344 5240                addq.w  #1,D0          plus 1 equals number of lines
FC4346 3080                move.w  D0,(A0)        as INTOUT[0]
FC4348 4E75                rts

**************************************************** VDI ESC 17, hardcopy
FC434A 3F3C0014            move.w  #$14,-(A7)     Hardcopy
FC434E 4E4E                trap    #14            XBIOS
FC4350 548F                addq.l  #2,A7          Correct stack pointer
FC4352 4E75                rts

**************************************************** VDI ESC 3, Enter alpha mode
FC4354 6108                bsr     $FC435E        ESC E, Clear home, clear screen
FC4356 60000224            bra     $FC457C        ESC e, Cursor on

**************************************************** VDI ESC 2, Exit alpha mode
FC435A 61000266            bsr     $FC45C2        ESC f, Cursor off

**************************************************** ESC E, Clear home
FC435E 615E                bsr     $FC43BE        ESC H, Cursor home
FC4360 6064                bra     $FC43C6        ESC J, Clear rest of screen

**************************************************** ESC A, VDI ESC 4, Cursor up
FC4362 323900002920        move.w  $2920,D1       Current cursor line
FC4368 67DE                beq     $FC4348        Zero, done
FC436A 5341                subq.w  #1,D1          Subtract one
FC436C 30390000291E        move.w  $291E,D0       Current cursor column
FC4372 60000606            bra     $FC497A        Set cursor

**************************************************** ESC B, VDI ESC 5, Cursor down
FC4376 323900002920        move.w  $2920,D1       Current cursor line
FC437C B27900002910        cmp.w   $2910,D1       Maximum cursor line
FC4382 67C4                beq     $FC4348        Already in lowest line?
```

```
FC4384 5241              addq.w   #1,D1       Increment by one
FC4386 30390000291E      move.w   $291E,D0    Current cursor column
FC438C 600005EC          bra      $FC497A     Set cursor

************************************************************ ESC C, VDI ESC 6, Cursor right
FC4390 30390000291E      move.w   $291E,D0    Current cursor column
FC4396 B0790000290E      cmp.w    $290E,D0    Maximum cursor column
FC439C 67AA              beq      $FC4348     Already in last column?
FC439E 5240              addq.w   #1,D0       Increment by one
FC43A0 323900002920      move.w   $2920,D1    Current cursor line
FC43A6 600005D2          bra      $FC497A     Set cursor

************************************************************ ESC D, BS, VDI ESC 7, Cursor left
FC43AA 30390000291E      move.w   $291E,D0    Current cursor column
FC43B0 6796              beq      $FC4348     Cursor already in first column?
FC43B2 5340              subq.w   #1,D0       Subtract one
FC43B4 323900002920      move.w   $2920,D1    Current cursor line
FC43BA 600005BE          bra      $FC497A     Set cursor

************************************************************ ESC H, VDI ESC 8, Cursor home
FC43BE 7000              moveq.l  #0,D0       Column 0
FC43C0 3200              move.w   D0,D1       Line 0
FC43C2 600005B6          bra      $FC497A     Set cursor

************************************************************ ESC J, VDI ESC 9, Clear rest of screen
FC43C6 612A              bsr      $FC43F2     ESC K, Clear rest of line
FC43C8 323900002920      move.w   $2920,D1    Current cursor line
FC43CE B27900002910      cmp.w    $2910,D1    Maximum cursor line
FC43D4 6700FF72          beq      $FC4348
FC43D8 5241              addq.w   #1,D1
FC43DA 4841              swap     D1
FC43DC 323C0000          move.w   #0,D1
```

```
FC43E0 343900002910         move.w  $2910,D2        Maximum cursor line
FC43E6 4842                 swap    D2
FC43E8 34390000290E         move.w  $290E,D2        Maximum cursor column
FC43EE 60000436             bra     $FC4826         Clear screen area

*****************************************************
FC43F2 08B9000300002934     bclr    #3,$2934        ESC K, VDI ESC 10, Clear rest of line
                                                    Cursorflag, clear wrap
FC43FA 40E7                 move.w  SR, -(A7)       Save old value
FC43FC 610001C4             bsr     $FC45C2         ESC f, Cursor off
FC4400 610001E0             bsr     $FC45E2         ESC j, Store cursor position
FC4404 32390000291E         move.w  $291E,D1        Current cursor column
FC440A 08010000             btst    #0,D1
FC440E 6716                 beq     $FC4426
FC4410 B2790000290E         cmp.w   $290E,D1        Maximum cursor column
FC4416 673A                 beq     $FC4452
FC4418 323C0020             move.w  #$20,D1         Blank
FC441C 6100035E             bsr     $FC477C         Output
FC4420 32390000291E         move.w  $291E,D1        Current cursor column
FC4426 4841                 swap    D1
FC4428 323900002920         move.w  $2920,D1        Current cursor line
FC442E 3401                 move.w  D1,D2
FC4430 4841                 swap    D1
FC4432 4842                 swap    D2
FC4434 34390000290E         move.w  $290E,D2        Maximum cursor column
FC443A 610003EA             bsr     $FC4826         Clear screen area
FC443E 44DF                 move.w  (A7)+,CCR       Restore flag
FC4440 6708                 beq     $FC444A         Not set?
FC4442 08F9000300002934     bset    #3,$2934        Cursorflag, set wrap
FC444A 610001B2             bsr     $FC45FE         ESC k, Restore cursor position
FC444E 60000160             bra     $FC45B0         Turn cursor back on
FC4452 323C0020             move.w  #$20,D1         Blank
FC4456 61000324             bsr     $FC477C         output
```

```
FC445A 60E2             bra      $FC443E

*****************************************************  VDI ESC 11, Set cursor
FC445C 207900002942     move.l   $2942,A0              Address of the INTIN array
FC4462 3210             move.w   (A0),D1               Get line
FC4464 5341             subq.w   #1,D1                 Subtract offset
FC4466 30280002         move.w   2(A0),D0              Get column
FC446A 5340             subq.w   #1,D0                 Subtract offset
FC446C 6000050C         bra      $FC497A               Set cursor

*****************************************************  VDI ESC 12, Text output
FC4470 20790000293E     move.l   $293E,A0              Address of the CONTRL array
FC4476 30280006         move.w   6(A0),D0              Number of characters
FC447A 207900002942     move.l   $2942,A0              Address of the INTIN array
FC4480 600E             bra      $FC4490               To end of loop
FC4482 3218             move.w   (A0)+,D1              Get characters in D1
FC4484 48E78080         movem.l  D0/A0,-(A7)           Save registers
FC4488 6100FD26         bsr      $FC41B0               Output character in D1
FC448C 4CDF0101         movem.l  (A7)+,D0/A0           Restore registers
FC4490 51C8FFF0         dbra     D0,$FC4482            Output next character
FC4494 4E75             rts

*****************************************************  ESC p, VDI ESC 13, Reverse on
FC4496 08F9000400002934 bset     #4,$2934              Cursor flag, set reverse
FC449E 4E75             rts

*****************************************************  ESC q, VDI ESC 14, Reverse off
FC44A0 08B9000400002934 bclr     #4,$2934              Cursor flag, clear reverse
FC44A8 4E75             rts

*****************************************************  VDI ESC 15, Get cursor position
FC44AA 20790000293E     move.l   $293E,A0              Address of the CONTRL array
```

```
FC44B0 317C00020008        move.w  #2,8(A0)        2 result values
FC44B6 20790000294A        move.l  $294A,A0        Address of the INTOUT array
FC44BC 303900002920        move.w  $2920,D0        Current cursor line
FC44C2 5240                addq.w  #1,D0           plus offset
FC44C4 3080                move.w  D0,(A0)         as INTOUT[0]
FC44C6 30390000291E        move.w  $291E,D0        Current cursor column
FC44CC 5240                addq.w  #1,D0           plus offset
FC44CE 31400002            move.w  D0,2(A0)        as INTOUT[1]
FC44D2 4E75                rts
*******************************************************  VDI ESC 16, Inquire tablet status
FC44D4 20790000293E        move.l  $293E,A0        Address of CONTRL array
FC44DA 317C00010008        move.w  #1,8(A0)        One result value
FC44E0 20790000294A        move.l  $294A,A0        Address of the INTOUT array
FC44E6 30BC0001            move.w  #1,(A0)         Tablet available
FC44EA 4E75                rts

*******************************************************  VDI ESC 18, Set graphic cursor
FC44EC 207900002942        move.l  $2942,A0        Address of the INTIN array
FC44F2 30BC0000            move.w  #0,(A0)         No result value
FC44F6 4EF900FCAFCA        jmp     $FCAFCA         Turn mouse cursor off

*******************************************************  VDI ESC 19, Clear graphic cursor
FC44FC 4EF900FCAFF2        jmp     $FCAFF2         Turn mouse cursor off

*******************************************************  ESC I, Cursor up, scroll if necessary
FC4502 323900002920        move.w  $2920,D1        Current cursor line
FC4508 6600FE60            bne     $FC436A         Not in line 0, cursor up
FC450C 3F390000291E        move.w  $291E,-(A7)     Save current cursor column
FC4512 6108                bsr     $FC451C         ESC L, insert line
FC4514 301F                move.w  (A7)+,D0        Restore cursor column
FC4516 7200                moveq.l #0,D1           Line 0
FC4518 60000460            bra     $FC497A         Set cursor
```

```
***************************************************  ESC L, Insert line
FC451C 610000A4          bsr     $FC45C2       ESC f, Cursor off
FC4520 323900002920      move.w  $2920,D1      Current cursor line
FC4526 6100058A          bsr     $FC4AB2       Scroll rest of screen down
FC452A 4240              clr.w   D0            Column 0
FC452C 323900002920      move.w  $2920,D1      Current cursor line
FC4532 61000446          bsr     $FC497A       Set cursor
FC4536 6078              bra     $FC45B0       Turn cursor on again

***************************************************  ESC M, Delete line
FC4538 61000088          bsr     $FC45C2       ESC f, Cursor off
FC453C 323900002920      move.w  $2920,D1      Current cursor line
FC4542 61000526          bsr     $FC4A6A       Move rest of screen up
FC4546 60E2              bra     $FC452A

***************************************************  Set background color
FC4548 C07C000F          and.w   #$F,D0        Color 0-15
FC454C 33C000002916      move.w  D0,$2916      Type color
FC4552 4E75              rts

***************************************************  Set background color
FC4554 C07C000F          and.w   #$F,D0        Color 0-15
FC4558 33C000002914      move.w  D0,$2914      Background color
FC455E 4E75              rts

***************************************************  ESC d, Clear screen to cursor
FC4560 610000D4          bsr     $FC4636       ESC o, Clear line to cursor
FC4564 343900002920      move.w  $2920,D2      Current cursor line
FC456A 67F2              beq     $FC455E       Zero, done
FC456C 5342              subq.w  #1,D2
FC456E 4842              swap    D2
```

```
FC4570 34390000290E        move.w  $290E,D2          Maximum cursor column
FC4576 7200                moveq.l #0,D1
FC4578 600002AC            bra     $FC4826           Clear screen area
******************************************************  ESC e, Turn cursor on
FC457C 4A79000027E0        tst.w   $27E0             Cursor already on?
FC4582 67DA                beq     $FC455E           Yes, done
FC4584 4279000027E0        clr.w   $27E0             Clear number of hide calls
FC458A 41F900002934        lea     $2934,A0          Cursor flag
FC4590 08100000            btst    #0,(A0)
FC4594 660E                bne     $FC45A4
FC4596 08D00002            bset    #2,(A0)
FC459A 227900002918        move.l  $2918,A1          Screen address of the cursor
FC45A0 60000456            bra     $FC49F8           Invert character at cursor position

FC45A4 61F4                bsr     $FC459A           Invert character at cursor position
FC45A6 08D00001            bset    #1,(A0)
FC45AA 08D00002            bset    #2,(A0)
FC45AE 4E75                rts

******************************************************
FC45B0 4A79000027E0        tst.w   $27E0             Cursor on ?
FC45B6 67A6                beq     $FC455E           Yes, rts
FC45B8 5379000027E0        subq.w  #1,$27E0          Decrement number of hide calls
FC45BE 67CA                beq     $FC458A           Turn on again
FC45C0 4E75                rts

******************************************************  ESC f, Cursor off
FC45C2 5279000027E0        addq.w  #1,$27E0          Increment number of hide calls
FC45C8 41F900002934        lea     $2934,A0          Cursor flag
FC45CE 08900002            bclr    #2,(A0)           Cursor not visible
FC45D2 678A                beq     $FC455E           Cursor was already off
FC45D4 08100000            btst    #0,(A0)           Cursor flashing ?
```

```
FC45D8 67C0              beq     $FC459A          No
FC45DA 08900001          bclr    #1,(A0)          Cursor not visible
FC45DE 66BA              bne     $FC459A          Invert character at cursor position
FC45E0 4E75              rts

*****************************************************   ESC j, Save cursor position
FC45E2 08F9000500002934  bset    #5,$2934         Cursor flag, position saved
FC45EA 41F9000027EC      lea     $27EC,A0         Address of the save area
FC45F0 30F90000291E      move.w  $291E,(A0)+      Current cursor column
FC45F6 30B900002920      move.w  $2920,(A0)       Current cursor line
FC45FC 4E75              rts

*****************************************************   ESC k, Cursor to saved position
FC45FE 08B9000500002934  bclr    #5,$2934         Cursor flag, position saved?
FC4606 6700FDB6          beq     $FC43BE          No, Cursor home
FC460A 41F9000027EC      lea     $27EC,A0         Address of the save area
FC4610 3018              move.w  (A0)+,D0         Cursor column
FC4612 3210              move.w  (A0),D1          Cursor line
FC4614 60000364          bra     $FC497A          Set cursor

*****************************************************   ESC l, Delete line
FC4618 61A8              bsr     $FC45C2          ESC f, Turn cursor off
FC461A 323900002920      move.w  $2920,D1         Current cursor line
FC4620 3401              move.w  D1,D2
FC4622 4841              swap    D1
FC4624 4241              clr.w   D1
FC4626 4842              swap    D2
FC4628 34390000290E      move.w  $290E,D2         Maximum cursor column
FC462E 610001F6          bsr     $FC4826          Clear screen area
FC4632 6000FEF6          bra     $FC452A          Cursor in colun zero

*****************************************************   ESC o, Clear line to cursor
```

```
FC4636 618A                 bsr      $FC45C2       ESC f, Turn cursor off
FC4638 61A8                 bsr      $FC45E2       ESC j, Save cursor position
FC463A 34390000291E         move.w   $291E,D2      Current cursor column
FC4640 6730                 beq      $FC4672       Zero, done
FC4642 08020000             btst     #0,D2
FC4646 6610                 bne      $FC4658
FC4648 323C0020             move.w   #$20,D1       Blank
FC464C 6100012E             bsr      $FC477C       output
FC4650 34390000291E         move.w   $291E,D2      Current cursor column
FC4656 5542                 subq.w   #2,D2
FC4658 4842                 swap     D2
FC465A 343900002920         move.w   $2920,D2      Current cursor line
FC4660 3202                 move.w   D2,D1
FC4662 4842                 swap     D2
FC4664 4841                 swap     D1
FC4666 4241                 clr.w    D1
FC4668 610001BC             bsr      $FC4826       Clear screen area
FC466C 6190                 bsr      $FC45FE       ESC k, Cursor to saved position
FC466E 6000FF40             bra      $FC45B0       and turn cursor back on
FC4672 323C0020             move.w   #$20,D1       Blank
FC4676 61000104             bsr      $FC477C       output
FC467A 60F0                 bra      $FC466C

*****************************************************  ESC v, Turn line-wrap off
FC467C 08F9000300002934     bset     #3,$2934      Cursor flag, flag for new line
FC4684 4E75                 rts

*****************************************************  ESC w, Turn line-wrap on
FC4686 08B9000300002934     bclr     #3,$2934      Cursor flag, clear flag
FC468E 4E75                 rts

*****************************************************  CR, Cursor to column zero
```

```
FC4690 323900002920          move.w   $2920,D1             Current cursor line
FC4696 4240                  clr.w    D0                   Column zero
FC4698 600002E0              bra      $FC497A              Set cursor

******************************************************    LF, (VT, FF), Cursor down
FC469C 303900002920          move.w   $2920,D0             Current cursor line
FC46A2 B07900002910          cmp.w    $2910,D0             Maximum cursor line
FC46A8 6600FCCC              bne      $FC4376              Not in lowest line, just cursor down
FC46AC 6100FF14              bsr      $FC45C2              ESC f, Turn cursor off
FC46B0 4241                  clr.w    D1
FC46B2 610003B6              bsr      $FC4A6A              Scroll screen up
FC46B6 6000FEF8              bra      $FC45B0              and turn cursor back on

******************************************************    Flash cursor
FC46BA 41F900002934          lea      $2934,A0             Cursor flag
FC46C0 08100006              btst     #6,(A0)              Update flag set ?
FC46C4 662A                  bne      $FC46F0              Yes, do nothing
FC46C6 08100002              btst     #2,(A0)              Cursor turned on ?
FC46CA 6724                  beq      $FC46F0              No
FC46CC 08100000              btst     #0,(A0)              Cursor flashing ?
FC46D0 671E                  beq      $FC46F0              No
FC46D2 43F900002923          lea      $2923,A1             Cursor flash counter
FC46D8 5311                  subq.b   #1,(A1)              decrement
FC46DA 6614                  bne      $FC46F0              Run out?
FC46DC 12B900002922          move.b   $2922,(A1)           Reload cursor flash rate
FC46E2 08500001              bchg     #1,(A0)              Invert cursor phase
FC46E6 227900002918          move.l   $2918,A1             Screen address of the cursor
FC46EC 6000030A              bra      $FC49F8              Invert character at cursor position
FC46F0 4E75                  rts

******************************************************    Cursor configuration
FC46F2 302F0004              move.w   4(A7),D0             Function number
```

```
FC46F6 6BF8             bmi     $FC46F0               Negative, ignore
FC46F8 B07C0005         cmp.w   #5,D0                 Greater than 5 ?
FC46FC 6EF2             bgt     $FC46F0               Yes
FC46FE E340             asl.w   #1,D0                 Word access
FC4700 41F900FC4718     lea     $FC4718,A0            Base address of the table
FC4706 D0FB0004         add.w   $FC470C(PC,D0.w),A0   plus relative address
FC470A 4ED0             jmp     (A0)                  Execute routine

*****************************************************  Jump table for cursor configuration
FC470C 0000             dc.w    $FC4718-$FC4718
FC470E 0004             dc.w    $FC471C-$FC4718
FC4710 0008             dc.w    $FC4720-$FC4718
FC4712 0016             dc.w    $FC472E-$FC4718
FC4714 0024             dc.w    $FC473C-$FC4718
FC4716 002C             dc.w    $FC4744-$FC4718

*****************************************************  0
FC4718 6000FEA8         bra     $FC45C2               ESC f, Turn cursor on

*****************************************************  1
FC471C 6000FE5E         bra     $FC457C               ESC e, Turn cursor on
*****************************************************  2
FC4720 6100FEA0         bsr     $FC45C2               ESC f, Turn cursor off
FC4724 08ED00002934     bset    #0,$2934(A5)          Cursor flag
FC472A 6000FE84         bra     $FC45B0               And back on

*****************************************************  3
FC472E 6100FE92         bsr     $FC45C2               ESC f, Turn cursor off
FC4732 08AD00002934     bclr    #0,$2934(A5)          Cursor flag
FC4738 6000FE76         bra     $FC45B0               And back on

*****************************************************  4
```

```
FC473C 1B6F00072922        move.b  7(A7),$2922(A5)    Set cursor flash rate
FC4742 4E75                rts

*******************************************************  5
FC4744 7000                moveq.l #0,D0
FC4746 102D2922            move.b  $2922(A5),D0       Load cursor flash rate
FC474A 4E75                rts

*******************************************************  Calculate font data for character in D1
FC474C 36390000292A        move.w  $292A,D3           Smallest ASCII code in font
FC4752 B243                cmp.w   D3,D1              Compare with character to output
FC4754 6522                bcs     $FC4778            Character not in font
FC4756 B27900002928        cmp.w   $2928,D1           Largest ASCII code in font
FC475C 621A                bhi     $FC4778            Character not in font
FC475E 207900002930        move.l  $2930,A0           Pointer to offset data
FC4764 D241                add.w   D1,D1              Code times 2
FC4766 32301000            move.w  0(A0,D1.w),D1      Yields bit number in font
FC476A E649                lsr.w   #3,D1              Divided by 8 equals byte number
FC476C 207900002924        move.l  $2924,A0           Pointer to font data
FC4772 D0C1                add.w   D1,A0              Yields pointer to data for this character
FC4774 4243                clr.w   D3                 Flag for character present
FC4776 4E75                rts

FC4778 7601                moveq.l #1,D3              Character not in font
FC477A 4E75                rts

*******************************************************  ascout, ignore control codes
FC477C 61CE                bsr     $FC474C            Character in font?
FC477E 6702                beq     $FC4782            Yes
FC4780 4E75                rts
FC4782 227900002918        move.l  $2918,A1           Screen address of the cursor
FC4788 3E3900002914        move.w  $2914,D7           Background color
```

```
FC478E 4847            swap    D7              In upper word
FC4790 3E3900002916    move.w  $2916,D7        Type color in lower word
FC4796 0839000400002934 btst   #4,$2934        Cursor flag, reverse ?
FC479E 6702            beq     $FC47A2         No
FC47A0 4847            swap    D7              Exchange colors
FC47A2 08B9000200002934 bclr   #2,$2934        Cursor flag, character in flash phase?
FC47AA 40E7            move.w  SR, -(A7)       Save status
FC47AC 61000160        bsr     $FC490E         Write character to the screen
FC47B0 227900002918    move.l  $2918,A1        Screen address of the cursor
FC47B6 30390000291E    move.w  $291E,D0        Current cursor column
FC47BC 323900002920    move.w  $2920,D1        Current cursor line
FC47C2 6100026E        bsr     $FC4A32         Increment cursor position
FC47C6 6732            beq     $FC47FA         No CR/LF needed ?
FC47C8 303900002912    move.w  $2912,D0        Bytes per character line
FC47CE C0C1            mulu.w  D1,D0           times lines
FC47D0 22790000044E    move.l  $44E,A1         _v_bs_ad
FC47D6 D3C0            add.l   D0,A1           Yields address of the character
FC47D8 4240            clr.w   D0              Column 0
FC47DA B27900002910    cmp.w   $2910,D1        Cursor in lowest line?
FC47E0 640A            bcc     $FC47EC         Yes
FC47E2 D2F900002912    add.w   $2912,A1        Bytes per character line, next line
FC47E8 5241            addq.w  #1,D1           Increment line
FC47EA 600E            bra     $FC47FA

FC47EC 48E7C040        movem.l D0-D1/A1,-(A7)  Save registers
FC47F0 7200            moveq.l #0,D1           to line 0
FC47F2 61000276        bsr     $FC4A6A         Scroll screen up
FC47F6 4CDF0203        movem.l (A7)+,D0-D1/A1  Restore registers
FC47FA 23C900002918    move.l  A1,$2918        Screen address of the cursor
FC4800 33C00000291E    move.w  D0,$291E        Current cursor column
FC4806 33C100002920    move.w  D1,$2920        Current cursor line
FC480C 44DF            move.w  (A7)+,CCR       Restore status
FC480E 6714            beq     $FC4824         Flag not set?
```

```
FC4810 610001E6            bsr     $FC49F8        Invert character at cursor position
FC4814 08F9000100002934    bset    #1,$2934       Cursor flag, cursor visible
FC481C 08F9000200002934    bset    #2,$2934       Cursor flag, cursor in flash phase
FC4824 4E75                rts

*****************************************************     Clear screen area
FC4826 9481                sub.l   D1,D2
FC4828 3001                move.w  D1,D0          Cursor column
FC482A 4841                swap    D1             Cursor line
FC482C 61000098            bsr     $FC48C6        Calculate cursor position
FC4830 E242                asr.w   #1,D2
FC4832 36390000293A        move.w  $293A,D3       Number of screen planes
FC4838 0C430004            cmp.w   #4,D3          Low resolution ?
FC483C 6602                bne     $FC4840        No
FC483E 5343                subq.w  #1,D3          minus 1, yields 1, 2, 3
FC4840 3202                move.w  D2,D1
FC4842 5241                addq.w  #1,D1
FC4844 E761                asl.w   D3,D1
FC4846 34790000293C        move.w  $293C,A2       Number of bytes per screen line
FC484C 94C1                sub.w   D1,A2
FC484E 3202                move.w  D2,D1
FC4850 4842                swap    D2
FC4852 5242                addq.w  #1,D2
FC4854 C4F90000290C        mulu.w  $290C,D2       times height of a character
FC485A 5342                subq.w  #1,D2          als dbra counter
FC485C 4280                clr.l   D0
FC485E 3A3900002914        move.w  $2914,D5       Background color
FC4864 0C7900020000293A    cmp.w   #2,$293A       Number of screen planes
FC486C 6B44                bmi     $FC48B2        High resolution ?
FC486E 6728                beq     $FC4898        Medium resolution ?
*****************************************************     Low resolution
FC4870 E245                asr.w   #1,D5          Background color, bit 0 into carry
```

```
FC4872 4040          negx.w   D0              Bit set, invert word
FC4874 4840          swap     D0
FC4876 E245          asr.w    #1,D5           Background color, bit 1 into color
FC4878 4040          negx.w   D0              Bit set, invert word
FC487A 4283          clr.l    D3              Planes three and four
FC487C E245          asr.w    #1,D5           Background color, bit 2 into carry
FC487E 4043          negx.w   D3              Bit set, invert word
FC4880 4843          swap     D3
FC4882 E245          asr.w    #1,D5           Background color, bit 3 into carry
FC4884 4043          negx.w   D3              Bit set, invert word
FC4886 3A01          move.w   D1,D5           Number of long words per line
FC4888 22C0          move.l   D0,(A1)+        Color planes one and two
FC488A 22C3          move.l   D3,(A1)+        Color planes three and four
FC488C 51CDFFFA      dbra     D5,$FC4888      Next long word
FC4890 D3CA          add.l    A2,A1           Pointer to next raster line
FC4892 51CAFFF2      dbra     D2,$FC4886      Next raster line
FC4896 4E75          rts

*******************************************************   Medium resolution
FC4898 E245          asr.w    #1,D5           Background color, bit 0 into carry
FC489A 4040          negx.w   D0              Bit set, invert word
FC489C 4840          swap     D0
FC489E E245          asr.w    #1,D5           Background color, bit 1 into carry
FC48A0 4040          negx.w   D0              Bit set, invert word
FC48A2 3A01          move.w   D1,D5           Number of long words per line
FC48A4 22C0          move.l   D0,(A1)+        Color planes one and two
FC48A6 51CDFFFC      dbra     D5,$FC48A4      Next long word
FC48AA D3CA          add.l    A2,A1           Pointer to next raster line
FC48AC 51CAFFF4      dbra     D2,$FC48A2      Next raster line
FC48B0 4E75          rts
```

```
********************************************************   high resolution
FC48B2 E245              asr.w    #1,D5          Background color, bit 0 in carry
FC48B4 4040              negx.w   D0             Bit set, invert word
FC48B6 3A01              move.w   D1,D5          Number of long words per line
FC48B8 32C0              move.w   D0,(A1)+       Color plane one
FC48BA 51CDFFFC          dbra     D5,$FC48B8     Next long word
FC48BE D3CA              add.l    A2,A1          Pointer to next raster line
FC48C0 51CAFFF4          dbra     D2,$FC48B6     Next raster line
FC48C4 4E75              rts

********************************************************   Calculate cursor position (D0/D1)
FC48C6 36390000290E      move.w   $290E,D3       Maximum cursor column
FC48CC B640              cmp.w    D0,D3          Column value too large?
FC48CE 6A02              bpl      $FC48D2        No
FC48D0 3003              move.w   D3,D0          Replace with maximum value
FC48D2 363900002910      move.w   $2910,D3       Maximum cursor line
FC48D8 B641              cmp.w    D1,D3          Line value too large?
FC48DA 6A02              bpl      $FC48DE        No
FC48DC 3203              move.w   D3,D1          Replace with maximum value
FC48DE 36390000293A      move.w   $293A,D3       Number of screen planes
FC48E4 3A00              move.w   D0,D5          Column
FC48E6 08850000          bclr     #0,D5          Round to even value
FC48EA C6C5              mulu.w   D5,D3          Number of screen planes times cursor column
FC48EC 08000000          btst     #0,D0          Odd column?
FC48F0 6702              beq      $FC48F4        No
FC48F2 5283              addq.l   #1,D3          Add one
FC48F4 3A3900002912      move.w   $2912,D5       Bytes per character line
FC48FA CAC1              mulu.w   D1,D5          Times cursor line
FC48FC 22790000044E      move.l   $44E,A1        _v_bs_ad
FC4902 D3C5              add.l    D5,A1          plus line offset
FC4904 D3C3              add.l    D3,A1          plus column offset
FC4906 D2F90000291C      add.w    $291C,A1       plus offset from screen start
```

```
FC490C 4E75               rts

*****************************************************  Character from font on the screen
FC490E 34790000292C       move.w   $292C,A2            Width of font, formwidth
FC4914 36790000293C       move.w   $293C,A3            Number of bytes per screen line
FC491A 38390000290C       move.w   $290C,D4            Height of a character
FC4920 5344               subq.w   #1,D4               as dbra counter
FC4922 3C390000293A       move.w   $293A,D6            Number of screen planes
FC4928 5346               subq.w   #1,D6               as dbra counter
FC492A 3A04               move.w   D4,D5               Counter for raster lines
FC492C 2848               move.l   A0,A4               Font address of the character
FC492E 2A49               move.l   A1,A5               Screen address of the character
FC4930 E287               asr.l    #1,D7               Next bit back- and foreground color
FC4932 0807000F           btst     #15,D7              Bit set in background color?
FC4936 6706               beq      $FC493E             No
FC4938 642A               bcc      $FC4964             Foreground color not set?
FC493A 76FF               moveq.l  #-1,D3              Fore- and background colors set
FC493C 6004               bra      $FC4942

FC493E 6512               bcs      $FC4952             Foreground color set?
FC4940 7600               moveq.l  #0,D3               Fore and background cleared
FC4942 1A83               move.b   D3,(A5)             Set byte in video RAM
FC4944 DACB               add.w    A3,A5               Pointer to next raster line
FC4946 51CDFFFA           dbra     D5,$FC4942          Next raster line
FC494A 5449               addq.w   #2,A1               Pointer to next color plane
FC494C 51CEFFDC           dbra     D6,$FC492A          Next color plane
FC4950 4E75               rts

*****************************************************  Set foreground color only
FC4952 1A94               move.b   (A4),(A5)           Copy byte in font in video RAM
FC4954 DACB               add.w    A3,A5               Next raster line of the screen
FC4956 D8CA               add.w    A2,A4               Next raster line in font
```

```
FC4958 51CDFFF8        dbra    D5,$FC4952       Write next raster line
FC495C 5449            addq.w  #2,A1            Pointer to next color plane
FC495E 51CEFFCA        dbra    D6,$FC492A       Next color plane
FC4962 4E75            rts

****************************************************  Set background color only
FC4964 1614            move.b  (A4),D3          Get byte from font
FC4966 4603            not.b   D3               Invert
FC4968 1A83            move.b  D3,(A5)          and to screen
FC496A DACB            add.w   A3,A5            Next raster line on the screen
FC496C D8CA            add.w   A2,A4            Next raster line in font
FC496E 51CDFFF4        dbra    D5,$FC4964       Display next raster line
FC4972 5449            addq.w  #2,A1            Pointer to next color plane
FC4974 51CEFFB4        dbra    D6,$FC492A       Next color plane
FC4978 4E75            rts

****************************************************  Set cursor
FC497A B0790000290E    cmp.w   $290E,D0         Compare column with maximum value
FC4980 6306            bls     $FC4988          Smaller ?
FC4982 30390000290E    move.w  $290E,D0         Maximum cursor column
FC4988 B27900002910    cmp.w   $2910,D1         Compare line with maximum value
FC498E 6306            bls     $FC4996          Smaller ?
FC4990 323900002910    move.w  $2910,D1         Maximum cursor line
FC4996 33C00000291E    move.w  D0,$291E         Current cursor column
FC499C 33C100002920    move.w  D1,$2920         Current cursor line
FC49A2 41F900002934    lea     $2934,A0         Cursor flag
FC49A8 08100002        btst    #2,(A0)          Cursor in flash phase?
FC49AC 673E            beq     $FC49EC          No
FC49AE 08100000        btst    #0,(A0)          Cursor flashing ?
FC49B2 670A            beq     $FC49BE          No
FC49B4 08900002        bclr    #2,(A0)          Clear flag for flash phase
FC49B8 08100001        btst    #1,(A0)          Cursor visible ?
```

```
FC49BC 671E              beq     $FC49DC         No
FC49BE 227900002918      move.l  $2918,A1        Screen address of the old cursor
FC49C4 6132              bsr     $FC49F8         Invert character at cursor position
FC49C6 6100FEFE          bsr     $FC48C6         Calculate new cursor position
FC49CA 23C900002918      move.l  A1,$2918        Screen address of the new cursor
FC49D0 6126              bsr     $FC49F8         Invert character at cursor position
FC49D2 08F9000200002934  bset    #2,$2934        Cursor flag
FC49DA 4E75              rts
FC49DC 6100FEE8          bsr     $FC48C6         Calculate cursor position
FC49E0 23C900002918      move.l  A1,$2918        Screen address of the cursor
FC49E6 08D00002          bset    #2,(A0)         Cursor in flash phase
FC49EA 4E75              rts
FC49EC 6100FED8          bsr     $FC48C6         Calculate cursor position
FC49F0 23C900002918      move.l  A1,$2918        Screen addres of the cursor
FC49F6 4E75              rts

*********************************************************  Invert character at cursor position
FC49F8 34790000293C      move.w  $293C,A2        Number of bytes per screen line
FC49FE 38390000290C      move.w  $290C,D4        Height of a character
FC4A04 5344              subq.w  #1,D4           as dbra counter
FC4A06 3C390000293A      move.w  $293A,D6        Number of screen planes
FC4A0C 5346              subq.w  #1,D6           as dbra as counter
FC4A0E 08F9000600002934  bset    #6,$2934        Set cursor flag for update
FC4A16 3A04              move.w  D4,D5           Counter for raster lines
FC4A18 2849              move.l  A1,A4           Screen address of the cursor
FC4A1A 4614              not.b   (A4)            Invert byte
FC4A1C D8CA              add.w   A2,A4           Pointer to next raster line
FC4A1E 51CDFFFA          dbra    D5,$FC4A1A      Next raster line
FC4A22 5449              addq.w  #2,A1           Pointer to next color plane
FC4A24 51CEFFF0          dbra    D6,$FC4A16      Next color plane
FC4A28 08B9000600002934  bclr    #6,$2934        Clear cursor flag for update
FC4A30 4E75              rts
```

```
*******************************************************     Increment cursor position (D0/D1)
FC4A32 B0790000290E        cmp.w    $290E,D0                Cursor in last column?
FC4A38 6612                bne      $FC4A4C                 No
FC4A3A 0839000300002934    btst     #3,$2934                Cursor flag, overflow in next line?
FC4A42 6604                bne      $FC4A48                 Yes
FC4A44 4243                clr.w    D3                      Cursor still in same line
FC4A46 4E75                rts

FC4A48 7601                moveq.l  #1,D3                   CR/LF necessary
FC4A4A 4E75                rts

FC4A4C 5240                addq.w   #1,D0                   Next column
FC4A4E 08000000            btst     #0,D0                   Even column number?
FC4A52 6706                beq      $FC4A5A                 Yes, not in same word
FC4A54 5249                addq.w   #1,A1                   Increment addres by one
FC4A56 4243                clr.w    D3                      Cursor still in same line
FC4A58 4E75                rts

FC4A5A 36390000293A        move.w   $293A,D3                Number of screen planes
FC4A60 E343                asl.w    #1,D3                   times 2
FC4A62 5343                subq.w   #1,D3                   minus 1
FC4A64 D2C3                add.w    D3,A1                   Address of next position
FC4A66 4243                clr.w    D3                      Cursor still in same line
FC4A68 4E75                rts

*******************************************************     Scroll screen up at line D1
FC4A6A 26790000044E        move.l   $44E,A3                 _v_bs_ad
FC4A70 363900002912        move.w   $2912,D3                Bytes per character line
FC4A76 C6C1                mulu.w   D1,D3                   multiply by number of lines
FC4A78 47F33000            lea      0(A3,D3.w),A3           Address of the current line
FC4A7C 4441                neg.w    D1                      Current line
FC4A7E D27900002910        add.w    $2910,D1                Maximum cursor line - current line
```

```
FC4A84 363900002912       move.w  $2912,D3            Bytes per character line
FC4A8A 45F33000           lea     0(A3,D3.w),A2       Address of the last line
FC4A8E C6C1               mulu.w  D1,D3               Number of bytes to move
FC4A90 E443               asr.w   #2,D3               Divided by four, equals number of longs
FC4A92 6002               bra     $FC4A96
FC4A94 26DA               move.l  (A2)+,(A3)+         Copy screen lines
FC4A96 51CBFFFC           dbra    D3,$FC4A94          Next long word
FC4A9A 323900002910       move.w  $2910,D1            Maximum cursor line
FC4AA0 3401               move.w  D1,D2
FC4AA2 4841               swap    D1
FC4AA4 4842               swap    D2
FC4AA6 4241               clr.w   D1
FC4AA8 34390000290E       move.w  $290E,D2            Maximum cursor column
FC4AAE 6000FD76           bra     $FC4826             Clear last line

*****************************************************  Scroll screen down at line D1
FC4AB2 26790000044E       move.l  $44E,A3             _v_bs_ad
FC4AB8 363900002910       move.w  $2910,D3            Maximum cursor line
FC4ABE C6F900002912       mulu.w  $2912,D3            Bytes per character line
FC4AC4 47F33000           lea     0(A3,D3.w),A3       Address of the last line
FC4AC8 363900002912       move.w  $2912,D3            Bytes per character line
FC4ACE 45F33000           lea     0(A3,D3.w),A2       Address of the first line
FC4AD2 3001               move.w  D1,D0               Current line
FC4AD4 4440               neg.w   D0
FC4AD6 D07900002910       add.w   $2910,D0            Maximum cursor line
FC4ADC C6C0               mulu.w  D0,D3               times bytes per character line
FC4ADE E443               asr.w   #2,D3               Divided by 4 for long word counter
FC4AE0 6002               bra     $FC4AE4
FC4AE2 2523               move.l  -(A3),-(A2)         Copy screen lines
FC4AE4 51CBFFFC           dbra    D3,$FC4AE2          Next long word
FC4AE8 60B6               bra     $FC4AA0             Clear top line
```

```
******************************************************** VDI ESC 102, Initialize font parameters
FC4AEA 207900002942        move.l   $2942,A0         Address of INTIN array
FC4AF0 2050                move.l   (A0),A0          Address of the font header
FC4AF2 30280052            move.w   82(A0),D0        formhight, height of a character
FC4AF6 33C00000290C        move.w   D0,$290C         save
FC4AFC 32390000293C        move.w   $293C,D1         Number of bytes per screen line
FC4B02 C2C0                mulu.w   D0,D1            times height of a character
FC4B04 33C100002912        move.w   D1,$2912         yields bytes per character line
FC4B0A 7200                moveq.l  #0,D1
FC4B0C 323900002936        move.w   $2936,D1         Screen height in bits
FC4B12 82C0                divu.w   D0,D1            Divided by font height
FC4B14 5341                subq.w   #1,D1            minus 1
FC4B16 33C100002910        move.w   D1,$2910         yields maximum cursor line
FC4B1C 7200                moveq.l  #0,D1
FC4B1E 32390000292E        move.w   $292E,D1         Screen width in bits
FC4B24 82E80034            divu.w   52(A0),D1        Divide by maximum character width
FC4B28 5341                subq.w   #1,D1            minus 1
FC4B2A 33C10000290E        move.w   D1,$290E         yields maximum cursor column
FC4B30 33E80050000292C     move.w   80(A0),$292C     Width of the font, formwidth
FC4B38 33E80024000292A     move.w   36(A0),$292A     Smallest ASCII code in font
FC4B40 33E800260002928     move.w   38(A0),$2928     Largest ASCII code in font
FC4B48 23E8004C00002924    move.l   76(A0),$2924     Pointer to font data
FC4B50 23E8004800002930    move.l   72(A0),$2930     Pointer to offset data
FC4B58 4E75                rts

******************************************************** Initialize screen output
FCA7C4 10390000044C        move.b   $44C,D0          sshiftmd, screen resolution
FCA7CA C07C0003            and.w    #3,D0            Isolate bits 0 and 1
FCA7CE B07C0003            cmp.w    #3,D0            3 ?
FCA7D2 6604                bne      $FCA7D8          No
FCA7D4 303C0002            move.w   #2,D0            Replace with 2 (high resolution)
FCA7D8 3F00                move.w   D0,-(A7)         Save resolution
```

```
FCA7DA 6100007E           bsr      $FCA85A           Set parameters for screen resolution
FCA7DE 301F               move.w   (A7)+,D0          Restore resolution
FCA7E0 41F900FD2D00       lea      $FD2D00,A0        Address of the 8x8 system-font header
FCA7E6 B07C0002           cmp.w    #2,D0             High resolution ?
FCA7EA 6606               bne      $FCA7F2           No
FCA7EC 41F900FD375C       lea      $FD375C,A0        Else address of the 8x16 system-font header
FCA7F2 6100A2FE           bsr      $FC4AF2           Initialize font data
FCA7F6 33FCFFFF00002916   move.w   #$FFFF,$2916      Type color to black
FCA7FE 7000               moveq.l  #0,D0
FCA800 33C000002914       move.w   D0,$2914          Background color white
FCA806 33C00000291E       move.w   D0,$291E          Cursor column zero
FCA80C 33C000002920       move.w   D0,$2920          Cursor line zero
FCA812 33C00000291C       move.w   D0,$291C          Line offset zero
FCA818 20790000044E       move.l   $44E,A0           _v_bs_ad, screen address
FCA81E 23C800002918       move.l   A0,$2918          as cursor address
FCA824 13FC000100002934   move.b   #1,$2934          Set cursor flag
FCA82C 13FC001E00002923   move.b   #$1E,$2923        Cursor flash counter to 30
FCA834 13FC001E00002922   move.b   #$1E,$2922        Cursor flash rate to 30
FCA83C 33FC0001000027E0   move.w   #1,$27E0          Cursor not visible
FCA844 323C1F3F           move.w   #$1F3F,D1         8000 long words
FCA848 20C0               move.l   D0,(A0)+          Clear screen
FCA84A 51C9FFFC           dbra     D1,$FCA848
FCA84E 23FC00FC41BC000004A8 move.l #$FC41BC,$4A8     constate vector to standard
FCA858 4E75               rts

*****************************************************  Set parameters for screen resolution
FCA85A 7200               moveq.l  #0,D1
FCA85C 123B0030           move.b   $FCA88E(PC,D0.w),D1   Get number of screen planes
FCA860 33C10000293A       move.w   D1,$293A          and save
FCA866 123B0029           move.b   $FCA891(PC,D0.w),D1   Get bytes per screen line
FCA86A 33C10000293C       move.w   D1,$293C          and save
FCA870 33C100002938       move.w   D1,$2938
```

```
FCA876 E340            asl.w   #1,D0                Resolution as word index
FCA878 323B001A        move.w  $FCA894(PC,D0.w),D1  Get screen height
FCA87C 33C100002936    move.w  D1,$2936             and save
FCA882 323B0016        move.w  $FCA89A(PC,D0.w),D1  Get screen width
FCA886 33C10000292E    move.w  D1,$292E             and save
FCA88C 4E75            rts

*************************************************** Screen parameters
FCA88E 040201          dc.b    4,2,1                Number of screen planes
FCA891 A0A050          dc.b    160,160,80           Number of bytes per screen line
FCA894 00C800C80190    dc.w    200,200,400          Screen height
FCA89A 014002800280    dc.w    320,640,640          Screen width
```

Chapter Four

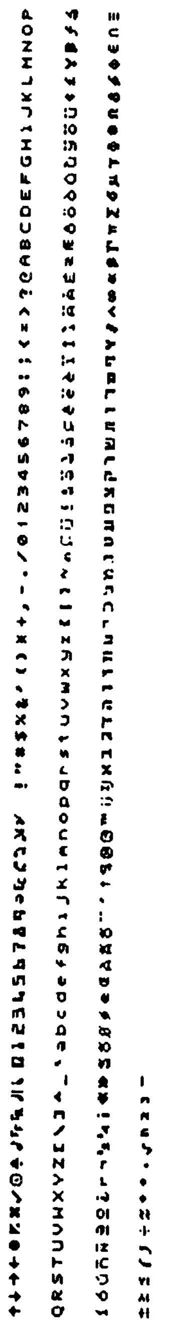
Appendix

4.1 The System Fonts

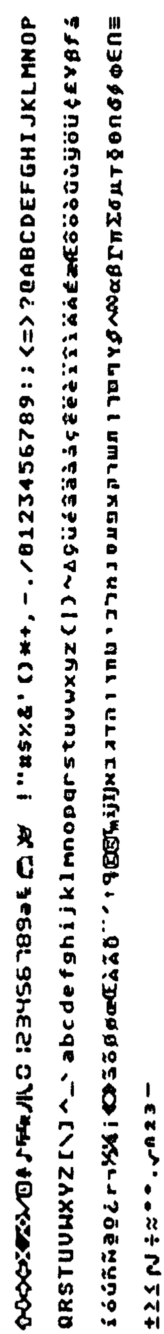
The operating system contains three different fonts for character output.

The 6x6 font is used by the icons, the 8x8 font is used as the standard output on a color monitor, and the 8x16 font is used for the monochrome monitor output. The chart on the next page includes the characters with the ASCII codes 1 to 255.

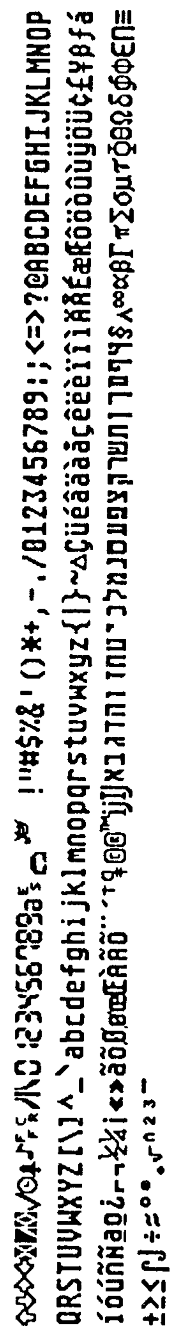
6X6 System Font



8X8 System Font



8X16 System Font



4.2 Alphabetical listing of GEMDOS functions

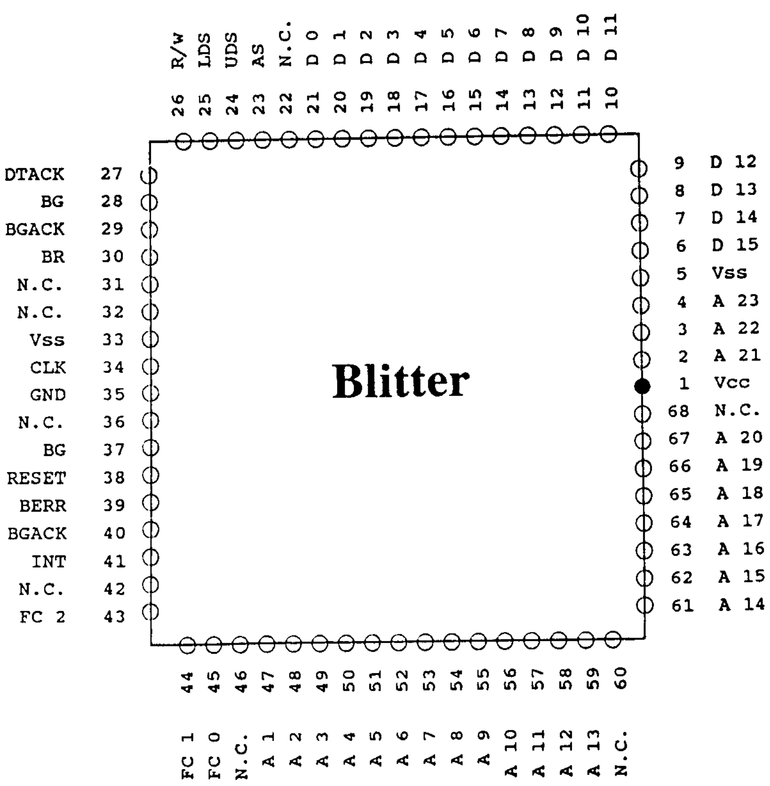
Malloc	48	135
Mfree	49	137
Mshrink	4A	137
Pexec	4B	138
Pterm	4C	140
Pterm0	00	107
Ptermres	31	121
Super	20	117
Sversion	30	121
Tgetdate	2A	118
Tgettime	2C	119
Tsetdate	2B	119
Tsettime	2D	120

4.3 The blitter chip

Anyone who has followed the development of the ST has surely heard the word *blitter*. More than two years were spent developing the blitter chip. The main advantage of this chip is its speed, working with data in the DMA register. The blitter uses a memory range independent of the 68000 microprocessor. Without the blitter chip, you need several kilobytes of program code to realize graphics through software.

The basic graphic routines of the ST are accessed by software through line-A opcodes. The blitter can take on parts of these routines and execute them faster than the 68000 could handle them. That is first taken by the BITBLT function, shifting the established pixel-oriented memory range. However, the fill can be taken up in any memory range. The details of the blitter options follow later. First let's look at chip design.

Figure 4.3-1 BLITTER



Since the blitter is a DMA device, it must be able to transfer the processor in an idle state. The processor needs the 68000 pins BR (Bus Request), BG (Bus Grant) and BGACK (Bus Grant Acknowledge). The BG pin conveys everything needed for the address and data bus. If the processor recognizes a Bus Request, BG tells the attached device that there is now a bus available for the DMA device. Now a short delay loop executes until the 68000 stops its activity in the different pins (see Section 1.2). As long as the DMA entry has established that the processor is no longer active, then it restarts with the help of BGACK. After data transfer finishes, BGACK clears, and the processor receives control of the bus.

The blitter chip can use the entire address range of the 68000 (16 megabytes). In order to manipulate the data in memory through programming, the processor cannot produce any control signals. These controlled by the READ/WRITE pin, which determines which data is read and which is written to memory. Other important signals for accessing memory are AS (Address Strobe), LDS (Lower Data Strobe) and UDS (Upper Data Strobe).

The DTACK signal (Data Transfer Acknowledge) invokes the blitter chip only, when the processor displays the transfer of data. It cannot do the DMA transfer itself, since the RAM chip timing is set by the blitter or the CLK signal. Like the other onboard DMA channels (floppy disk and DMA port) and the ACIAs, the blitter is also capable of performing interrupts. This means that it can create its own interrupts to end data transfers. Therefore, it uses the free bit 3 of the MFP interrupt entry (GPIP). This option is not usually used by the ST operatng system. However, other interrupt-oriented operating systems like RTOS, OS9 or UNIX should have blitter integration.

The last group of blitter connections belong to the power connections. In addition to the usual 5 volt current and ground, the blitter needs a time signal of 8 mHz.

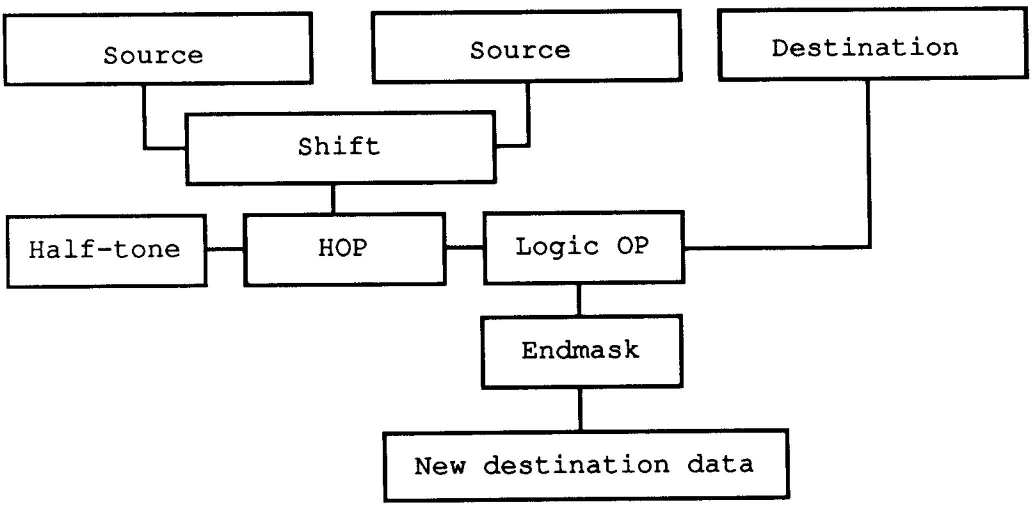
4.3.1 The blitter registers

The ST blitter chip is the hardware implementation of the BITBLT algorithm used in the line-A opcodes.

Figure 4.3.1-1 shows a block diagram of the blitter functions. The blitter can basically set up a source range which can be combined with a current raster, a destination range of 16 different logical operands, and a destination range in which it stores the result. Both source and destination ranges can be stored in the same area of RAM. Unlike the processor, which can only operate in bytes and words, the blitter is bit-oriented. This makes the blitter ideal for handling bitmapped graphics. It is also practical for normal copy and transfer commands, e.g., high-speed RAM disk operations without hard disk interrupts.

The following is a look at the individual registers used by the blitter:

Figure 4.3.1-1 BLITTER BLOCK DIAGRAM



The first 16 registers are marked as half-tone RAM, and contain the raster used in half-tone operations. The registers are each 16 bits wide. When the raster is used, a proportional register for a lin is used. The raster repeats over all 16 lines. The Line Number register (see below) determines which half-tone register is used next.

```
        Bit  F E D C B A 9 8 7 6 5 4 3 2 1 0
$FF8A00 R/W  X X X X X X X X X X X X X X X X Half-tone RAM  0
$FF8A02 R/W  X X X X X X X X X X X X X X X X Half-tone RAM  1
$FF8A04 R/W  X X X X X X X X X X X X X X X X Half-tone RAM  2
$FF8A06 R/W  X X X X X X X X X X X X X X X X Half-tone RAM  3
$FF8A08 R/W  X X X X X X X X X X X X X X X X Half-tone RAM  4
$FF8A0A R/W  X X X X X X X X X X X X X X X X Half-tone RAM  5
$FF8A0C R/W  X X X X X X X X X X X X X X X X Half-tone RAM  6
$FF8A0E R/W  X X X X X X X X X X X X X X X X Half-tone RAM  7
$FF8A10 R/W  X X X X X X X X X X X X X X X X Half-tone RAM  8
$FF8A12 R/W  X X X X X X X X X X X X X X X X Half-tone RAM  9
$FF8A14 R/W  X X X X X X X X X X X X X X X X Half-tone RAM 10
$FF8A16 R/W  X X X X X X X X X X X X X X X X Half-tone RAM 11
$FF8A18 R/W  X X X X X X X X X X X X X X X X Half-tone RAM 12
$FF8A1A R/W  X X X X X X X X X X X X X X X X Half-tone RAM 13
$FF8A1C R/W  X X X X X X X X X X X X X X X X Half-tone RAM 14
$FF8A1E R/W  X X X X X X X X X X X X X X X X Half-tone RAM 15
```

The next register is called X Increment. This is a leading character dependent 15-bit register. The lowest bit is ignored and constantly registers 0. This makes only even numbers possible. The register gives the offset in bytes in the next source word in the same line. Normally, the Atari gives a 2 for monochrome mode. This is also the case when all planes are copied in color mode. If a plane is copied in medium-res or low-res mode,then 4 or 8 must exist in this register.

```
        Bit  F E D C B A 9 8 7 6 5 4 3 2 1 0
$FF8A20 R/W  X X X X X X X X X X X X X X X 0   Source X
                                           |   Increment
                    (always zero, even increments only)
```

The Source Y Increment register determines how many bytes must be added to the current source address, in order to figure out the distance from the end of the current line to the start of the next line.In monochrome mode, a set of pixels measures 80 bytes: When only a segment of 20 bytes is copied, the Source Y Increment gives a value of 60.

```
        Bit  F E D C B A 9 8 7 6 5 4 3 2 1 0
$FF8A22 R/W  X X X X X X X X X X X X X X X 0   Source Y
                                           |   Increment
                    (always zero, even increments only)
```

The Source Address register determines the starting address at the beginning of the copy. It can read or write long word accesses. Bits 0 and 24-31 are used only for even 24- bit addresses. The contents of this register are incremented as part of the operation with the help of the above mentioned increment register (or decremented, depending on the leading character of the increment register). By reading the source address register, the address of the source word used next is received.

```
        Bit  F E D C B A 9 8 7 6 5 4 3 2 1 0
$FF8A24 R/W  - - - - - - - - X X X X X X X 0  Source Address
                                              High   Word
          (unused)      (24-bit addresses only)

        Bit  F E D C B A 9 8 7 6 5 4 3 2 1 0
$FF8A26 R/W  X X X X X X X X X X X X X X X 0  Source Address
                                            |  Low word
                          (always zero, even increments only)
```

The next three registers contain the endmask, which states which bits are changed and which are unchanged.Since the blitter is pixel oriented, but the bus accesses RAM in words, the first and the last word are read as bits. To write 16 bits over the processor bus, the destination word must first read then change the allowable bits, and transfer the result (Read-Modify-Write). Endmask 1 does this for the beginning of a line, endmask 3 applies to the end of a line. Endmask 2 is used by all other words. It is normally set to $FFFF (all bits are altered by it). Thus, a previous reading of the destination word is unnecessary.

```
        Bit  F E D C B A 9 8 7 6 5 4 3 2 1 0
$FF8A28 R/W  X X X X X X X X X X X X X X X X   Endmask 1
$FF8A2A R/W  X X X X X X X X X X X X X X X X   Endmask 2
$FF8A2C R/W  X X X X X X X X X X X X X X X X   Endmask 3
```

The next three registers are Destination X Increment, Destination Y Increment and Destination Address. They have the same uses as the above-mentioned source registers, except that these three apply to the destination.

```
        Bit  F E D C B A 9 8 7 6 5 4 3 2 1 0
$FF8A2E R/W  X X X X X X X X X X X X X X X 0  Destination X
                                            |  Increment
                          (always zero, even increments only)
```

```
        Bit  F E D C B A 9 8 7 6 5 4 3 2 1 0
$FF8A30 R/W  X X X X X X X X X X X X X X X 0  Destination Y
                                           |  Increment
                        (always zero, even increments only)

        Bit  F E D C B A 9 8 7 6 5 4 3 2 1 0
$FF8A32 R/W  - - - - - - - - X X X X X X X X Destination
                                             Address High Word
             (unused)       (24-bit addresses only)

        Bit  F E D C B A 9 8 7 6 5 4 3 2 1 0
$FF8A34 R/W  X X X X X X X X X X X X X X X 0 Destination
                                           | Address Low Word
                        (always zero, even increments only)
```

The X Count register informs you how many words are in a destination line. The minimum value is 1; the highest is 65536 ($0000). Reading the register gives the number of values in this line as words are transferred. When the X Count register is loaded with 1, the values in Destination X Increment, as well as Source X Increment, are unused. Since the line after a word is already the end, and the corresponding Y Increment is used direct.

The Y Count register determines the number of lines. The smallest value is again one, and values of zero are interpreted as 65536. Reading this register gives you the number of lines which need copying. After every transferred line, the value decrements by one until it reaches 0, ending the transfer.

```
        Bit  F E D C B A 9 8 7 6 5 4 3 2 1 0
$FF8A36 R/W  X X X X X X X X X X X X X X X X  X-Count
$FF8A38 R/W  X X X X X X X X X X X X X X X X  Y-Count
```

All the abovementioned registers can only be read as words or long words; byte access is not allowed.

The HOP register determines the combination of source and half-tone RAM. The two lowest bits have the following meanings:

HOP	Combination
0	All 1-bits
1	Half-tone RAM
2	Source
3	Source and half-tone RAM

You can therefore determine whether the source can be used unaltered (HOP = 2), whether the half-tone RAM is combined with the logical AND (HOP = 3) or whether only the half-tone RAM is used (HOP =1). This is useful, for example, when filling an area with a raster pattern. Furthermore, it is still possible to fill the destination with 1-bits (HOP = 0). When half-tone RAM is used, another register determines which half-tone registers are used.

```
             Bit     7 6 5 4 3 2 1 0
$FF8A3A      R/W     - - - - - - X X        HOP
                                            Half-tone operation
```

The next register determines the receiver of the new destination value, after logical operations between destination and source. Here are 16 different options in the following table.

(~s&~d) |	(~s&d) |	(s&~d) |	(s&d)	Operation	New destination
0	0	0	0	0	all 0 bits
0	0	0	1	1	source AND destination
0	0	1	0	2	source AND NOT destination
0	0	1	1	3	source
0	1	0	0	4	NOT source AND destination
0	1	0	1	5	destination
0	1	1	0	6	source XOR destination
0	1	1	1	7	source OR destination
1	0	0	0	8	NOT source AND NOT destination
1	0	0	1	9	NOT source XOR destination
1	0	1	0	10	NOT destination
1	0	1	1	11	source OR NOT destination
1	1	0	0	12	NOT source
1	1	0	1	13	NOT source OR destination
1	1	1	0	14	NOT source OR NOT destination
1	1	1	1	15	all 1 bits

The most important operations are the following three (Replace mode, Source replaces and destination), 6 (XOR mode; overlapping of destination and source) and and 7 (OR mode).

```
             Bit     7 6 5 4 3 2 1 0
$FF8A3B      R/W     - - - - X X X X        OP
                                            Logical operation
```

```
             Bit     7 6 5 4 3 2 1 0
$FF8A3C      R/W     X X X - X X X X
                             |_|_|_|_______Line number
                           |_______________Unused
                         |_________________SMUDGE
                       |___________________HOG
                     |_____________________Busy
```

The next register combines several functions. The lowest 4 bits determine which of the 16 half-tone RAM registers are even used. The value is incremented or decremented after a line, depending on the leading character in the Destination Y Register.When the SMUDGE bit is set, the number of the half-tone RAM register is determined by the four lowest bits of the above mentioned source data. The selected half-tone operation (HOP) stays active. This allows special effects.

The next bit in this register determines the method of bus access in the blitter. When the HOG bit clears, the blitter and processor share the same bus. After 64 bus cycles, the blitter stops and the processor takes over the bus for 64 bus cycles. When the HOG bit is set, the processor stops until the blitter finishes its operations. In either case, other DMA devices (floppy and harddisk) have priority over the blitter. The Prefetch mechanism of the 68000 processor lets you bypass HOG mode, so after the start of the blitter the next processor command executes when the blitter is ready.

The BUSY bit is set, initializing all other blitter registers, in order to start the blitter. It waits until the blitter ends its operation. Since the interrupt output mirrors the status of the blitter, blitter operations can be ended by an interrupt taken from the third bit of the GPIP within the MFP 68901.

```
             Bit     7 6 5 4 3 2 1 0
$FF8A3D      R/W     X X - - X X X X
                             |_|_|_|_______SKEW
                         |_|_______________Unused
                       |___________________NFSR
                     |_____________________FXSR
```

The last blitter register also has several functions. The lowest four bits determine the source operand shifts, to protect the destination operations. Since the blitter is bit-oriented, but bus access is word-oriented, the source data must move to set the bit positions of half-tone masks and destination data. Therefore, two source data words are read, shifting the relevant bits for calling in a 16-bit source register (see Figure 4.3.1-1).

FXSR and NFSR are abbreviations for Force eXtra Source Read and No Final Source Read. When the FXSR bit is set, the beginning of each line is read as an additional source word. The NFSR bit is set when the last word of the source line cannot be read. The use of these bits require changes to Source Y Increment and Source Address Register.

Normally you can access the blitter directly through the operating system. When you use the line-A or VDI functions, the operating system can tell whether the function is produced by software or by the blitter (see XBIOS function $64).

4.4 The Mega ST realtime clock

When the ST was initially released, GEMDOS set the software-run clock in two-second increments. In addition, the clock and date needed resetting every time the user switched on the computer.

To get around this, the ROM circuits, keyboard processor and clock IC offered some solutions. The Mega ST's clock IC is a permanent solution to the problem. Its timekeeping registers are as follows:

```
          Bit  7 6 5 4 3 2 1 0      (bits 4-7 unused)
$FFFC21   R/W  - - - - X X X X      one second
$FFFC23   R/W  - - - - X X X X      ten seconds
$FFFC25   R/W  - - - - X X X X      one minute
$FFFC27   R/W  - - - - X X X X      ten minutes
$FFFC29   R/W  - - - - X X X X      one hour
$FFFC2B   R/W  - - - - X X X X      ten hours
$FFFC2D   R/W  - - - - X X X X      weekday
$FFFC2F   R/W  - - - - X X X X      one day
$FFFC31   R/W  - - - - X X X X      tenth day
$FFFC33   R/W  - - - - X X X X      one month
$FFFC35   R/W  - - - - X X X X      tenth month
$FFFC35   R/W  - - - - X X X X      one year
$FFFC37   R/W  - - - - X X X X      tenth year
$FFFC39   R/W  - - - - X X X X      control register
$FFFC3B   R/W  - - - - X X X X      control register
$FFFC3D   R/W  - - - - X X X X      control register
```

The RP 5 C 15 appears to be the same as most clock ICs. It has a four-bit-wide data and address bus,which addreses a total of 16 registers. All of these registers had data width of 4 bits, and contain areas of date and time in BCD format. The next three registers ($FFFC3B to $FFFC3F) are unknown. They describe some registers of setting the clock, but disassembly doesn't give any further information. Clock timing counts through a quartz oscillator running at a frequency of 32,768 kHz. This relatively slow IC is controlled through a PAL (programmable logic array).

All clock registers lie in the address area of the processor, offering a simple to read and accurate clock. The Mega ST's operating system and XBIOS functions determine theimselves whether the clock time is taken from the keyboard processor, or whether the hardware clock is available at all.

4.5 Blitter chip demonstration programs

This section contains programs demonstrating some of the blitter chip's abilities.

This sample program moves the screen memory to another location. The function blit is universal, however, you can blit any RAM. Try the program as a test only. The main purpose of this program is to show how to establish screen areas (forms) and pixel coordinates for the individual registers of the blitter. This program directly accesses the blitter, and must run in 68000 supervisor mode. If you attempt to run the program in user mode, a bus error occurs.

```
blitter   equ       $ff8a00

;         blitter register offsets

halftone  equ       0
src_xinc  equ       $20
src_yinc  equ       $22
src_addr  equ       $24
ENDMASK1  EQU       $28
endmask2  equ       $2a
endmask3  equ       $2c
dst_xinc  equ       $2e
dst_yinc  equ       $30
dst_addr  equ       $32
x_count   equ       $36
y_count   equ       $38
hop       equ       $3a
op        equ       $3b
line_num  equ       $3c
skew      equ       $3d

;         blitter register flags

flinebusy equ       7         ;busy bit

;         mask blitter register bit

mhop_src  equ       $02       ;half-tone operation: source

mskewfxsr equ       $80       ;fxsr mask
mskewnfsr equ       $40       ;nfsr mask
```

```
mlinebusy equ       $80       ;busy mask


physbase  equ       2         ;get screen address
xbios     equ       14

demo:
          lea       para,a4

          move      #physbase,-(sp)
          trap      #xbios
          addq.l    #2,sp               ;get screen address

          move.l    d0,src_form(a4)     ;screen acts as
          move.l    d0,dst_form(a4)     ;source and destination

          moveq     #2,d0               ;2 bytes offset
          move      d0,src_nxwd(a4)     ;to next word in
          move      d0,dst_nxwd(a4)     ;same color plane

          moveq     #80,d0              ;one line is 80 bytes long
          move      d0,src_nxln(a4)     ;(monochrome mode)
          move      d0,dst_nxln(a4)

          moveq     #2,d0               ;offset to next color plane
          move      d0,src_nxpl(a4)     ;not used in
          move      d0,dst_nxpl(a4)     ;monochrome mode

          move      #25,src_xmin(a4)    ;x1-coordinate source
          move      #34,src_ymin(a4)    ;y1-coordinate source

          move      #220,dst_xmin(a4)   ;x1-coordinate destination
          move      #234,dst_ymin(a4)   ;y1-coordinate destination

          move      #77,width(a4)       ;width in pixels
          move      #50,height(a4)      ;height-pixels (number of lines)
          move      #1,planes(a4)       ;monochrome

          jsr       blit_it             ;access blitter

          rts                           ;ready

para      dc.w      17                  ;room for parameter block

;         end maskn

lf_endmask:
```

```
          dc.w      $ffff

rt_endmask:
          dc.w      $7fff
          dc.w      $3fff
          dc.w      $1fff
          dc.w      $0fff
          dc.w      $07ff
          dc.w      $03ff
          dc.w      $01ff
          dc.w      $00ff
          dc.w      $007f
          dc.w      $003f
          dc.w      $001f
          dc.w      $000f
          dc.w      $0007
          dc.w      $0003
          dc.w      $0001
          dc.w      $0000

;
;         input: pointer to 34-byte parameter block in a4
;

src_form  equu      0         ;base address source memory form
src_nxwd  equ       4         ;offset next word in source
src_nxln  equ       6         ;source form width
src_nxpl  equ       8         ;offset between source planes
src_xmin  equ       10        ;source x1
src_ymin  equ       12        ;source y1

dst_form  equ       14        ;base address dest memory form
dst_nxwd  equ       18        ;offset next word in dest
dst_nxln  equ       20        ;dest form width
dst_nxpl  equ       22        ;offset between dst planes
dst_xmin  equ       24        ;dest x1
dst_ymin  equ       26        ;dest y1

width     equ       28        ;width in pixels
height    equ       30        ;height in pixels
planes    equ       32        ;number of planes

blit_it:
          lea       blitter,a5
```

```
;         compute xmax from xmin and width

          move      width(a4),d6
          subq      #1,d6                  ;width -1

          move      src_xmin(a4),d0
          move      d0,d1
          add       d6,d1                  ;src_xmax

          move      dst_xmin(a4),d2
          move      d2,d3
          add       d6,d3                  ;dst_xmax

          moveq     #$f,d6                 ;mod 16 mask

          move      d2,d4                  ;dst_xmin
          and       d6,d4                  ;dst_xmin mod 16
          add       d4,d4                  ;pointer to left end mask table
          move      lf_endmask(pc,d4),d4   ;left end mask

          move      d3,d5                  ;dst_xmax
          and       d6,d5                  ;dst_xmax mod 16
          add       d5,d5                  ;pointer to right end mask
                                           ;table
          move      rt_endmask(pc,d5),d5   ;inverted left end mask
          not       d5                     ;right end mask

;         calculate skew
;         ((dst_xmin mod 16) - (src_xmin mod 16)) mod 16
;
;         determine FXSR and NFSR
;
;         3 bit index in table
;
;         bit 0     0 src_xmin mod 16 >= dst_xmin mod 16
;                   1 src_xmin mod 16 >  dst_xmin mod 16
;
;         bit 1     0 src_xmax/16 - src_xmin/16 <> dst_xmax/16 -
;                   dst_xmin/16
;                   0 src_xmax/16 - src_xmin/16 <> dst_xmax/16 -
;                   dst_xmin/16
;
;         bit 2     0 dst_span equals several words
;                   1 dst_span equals one word
;

          move      d2,d7     ;dst_xmin
```

```
        and     d6,d7     ;dst_xmin mod 16
        and     d0,d6     ;src_xmin mod 16
        sub     d6,d7     ;dst_xmin mod 16 - src_xmin mod 16
;                          > ? cy = 1 : cy = 0
        clr     d6        ;delete index in table
        addx    d6,d6     ;cy after bit 0

        lsr     #4,d0     ;src_xmin / 16
        lsr     #4,d1     ;src_xmax / 16
        sub     d0,d1     ;src_span - 1

        lsr     #4,d2     ;dst_xmin / 16
        lsr     #4,d3     ;dst_xmax / 16
        sub     d2,d3     ;dst_span - 1

        bne     set_endmask

;       if
;       if dst_span = one word, both endmasks stand in endmask 1
;       the blitter ignores endmask 2

        and     d5,d4
        addq    #4,d6      ;d6 bit 2 = 1 one word destination

set_endmask:

        move    d4,endmask1(a5)      ;left endmask
        move    #$ffff,endmask2(a5);middle endmask
        move    d5,endmask3(a5)      ;right endmask

        cmp     d1,d3                ;number of source und dest words
                                     ;equal?
        bne     set_count            ;no

        addq    #2,d6                ;d6 bit 1 = 1 equal number of
                                     ;words

set_count:

        move    d3,d4
        addq    #1,d4                ;number of words in dest line
        move    d4,x_count(a5)

;
;       determine source start address
;
;       src_form + (src_ymin * src_nxln) * (src_xmin/16 * src_nxwd)
```

```
        move.l    src_form(a4),a0    ;a0 -> start src form
        move      src_ymin(a4),d4    ;offset in lines to ymin
        move      src_nxln(a4),d5    ;length src line
        mulu      d5,d4
        add.l     d4,a0              ;a0 -> (0, ymin)

        move      src_nxwd(a4),d4    ;offset of next word
        move      d4,src_xinc(a5)

        mulu      d4,d0
        add.l     d0,a0              ;a0 -> first word (xmin, ymin)

        mulu      d4,d1              ;source line length in bytes
        sub       d1,d5
        move      d5,src_yinc(a5)    ;offset next end line beginning

;       compute destination start address

        move.l    dst_form(a4),a1    ;a1 -> start dst form
        move      dst_ymin(a4),d4
        move      dst_nxln(a4),d5

        mulu      d5,d4
        add.l     d4,a1

        move      dst_nxwd(a4),d4
        move      d4,dst_xinc(a5)

        mulu      d4,d2
        add.l     d2,d1

;       compute dst yinc

        mulu      d4,d3
        sub       d3,d5
        move      d5,dst_yinc(a5)    ;destination y increment

        and.b     #$f,d7
        or.b      skew_flags(pc,d6),d7 ;skew-flags from table

        move.b    d7,skew(a5)        ;in blitter

        move.b    #mhop_src,hop(a5)  ;half-tone operation: source only
        move.b    #3,op(a5)          ;replace mode

        lea       line_num(a5),a2    ;pointer to line number register
```

```
        move.b   #flinebusy,d2        ;busy bit after d2
        move     planes(a4),d7        ;number of bitplanes
        bra      begin

skew_flags:
        dc.b     mskewnfsr
        dc.b     mskewfxsr
        dc.b     0
        dc.b     mskewnfsr+mskewfxsr

        dc.b     0
        dc.b     mskewfxsr
        dc.b     0
        dc.b     0

next_plane:

        move.l   a0,src_addr(a5)      ;load source address
        move.l   a1,dst_addr(a5)      ;load destination address
        move     height(a4),y_count(a5) ;number of lines

        move.b   #mlinebusy,(a2)      ;start blitter
        add      src_nxpl(a4),a0      ;start next src plane
        add      dst_nxpl(a4),a1      ;start next dst plane

restart:

        bset     d2,(a2)              ;restart blitter
        nop
        bne      restart              ;not ready yet?

begin   dbra     d7,next_plane        ;next bitplane

        rts
 end
```

Here are some extremely interesting sample programs for the BITBLT line-A command.

The first example defines a monochrome picture and copies it to a monchrome screen. The picture should appear on the screen starting at the coordinates X = 200 and Y = 100. This replaces the original screen contents using the replace mode. No raster is used, so the raster address is set to zero. The program looks like this:

```
;**********************************************************************
;         bitblt demo                                                  *
;         copy one-color source range to monochrome screen             *
;**********************************************************************

bitblt    equ       $a007     ;op code

b_width   equu       0        ;width in pixel
b_height  equ        2        ;height in pixel
planes    equ        4        ;number of colorplanes
fg_col    equ        6        ;foreground color
bg_col    equ        8        ;background color
op_tab    equ       10        ;logical operations

s_xmin    equ       14        ;x-coordinate in source
s_ymin    equ       16        ;y-coordinate in source
s_form    equ       18        ;address of source
s_nxwd    equ       22        ;offset of next word in source
s_nxln    equ       24        ;offset of next line in source
s_nxpl    equ       26        ;offset of next colorplane in source

d_xmin    equ       28        ;x-coordinate in destination
d_ymin    equ       30        ;y-coordinate in destination
d_form    equ       32        ;address of destination
d_nxwd    equ       36        ;offset of next word in destination
d_nxln    equ       38        ;offset of next line in destination
d_nxpl    equ       40        ;offset of next colorplane in
                              ;destination

p_addr    equ       42        ;address of raster used
p_nxln    equ       46        ;offset of next line in raster
p_nxpl    equ       48        ;offset of next colorplane in raster
p_mask    equ       50        ;raster index mask (number of lines)

physbase  equ        2
xbios     equ       14

do_blit   lea       para(pc),a6         ;pointer to parameter block

          move      #92,b_width(a6)     ;width in pixel
          move      #52,b_height(a6)    ;height in pixel

          move      #1,planes(a6)       ;monochrome

          move      #1,fg_col(a6)       ;foreground color
          move      #0,bg_col(a6)       ;background color
```

```
        move.l    #$03030303,op_tab(a6) ;replace mode

;                                   transfer source data
        move      #0,s_xmin(a6)      ;upper left corner of source
        move      #0,s_ymin(a6)
        move.l    #source,s_form(a6) ;source address

        move      #2,22(a6)          ;2 byte offset of next word
        move      #12,s_nxln(a6)     ;80 byte offset of next
                                     ;line
        move      #2,s_nxpl(a6)      ;2 byte offset of next
                                     ;colorplane

;                                    screen is destination

        move      #200,d_xmin(a6)    ;x-coordinate of screen
        move      #100,d_ymin(a6)    ;y-coordinate of screen

        move      #physbase,-(sp)
        trap      #xbios             ;get screen address
        addq.l    #2,sp

        move.l    d0,d_form(a6)      ;as destination address

        move      #2,d_nxwd(a6)      ;2 byte offset of next word
        move      #80,d_nxln(a6)     ;80 byte offset of next line
        move      #2,d_nxpl(a6)      ;2 byte offset of next
                                     ;colorplane

        clr.l     p_addr(a6)         ;no raster used

        dc.w      bitblt             ;execute bitblt
        rts

        align
para:   ds.b      76        ;76 byte parameter block

;       width  = 92          width of source in pixels
;       height = 52          height of source in pixels


source  dc.w      $AAAA,$AAAA,$AAAA,$AAAA,$AAAA,$AAA0
        dc.w      $5555,$5555,$5555,$5555,$5555,$5550
        dc.w      $AAAA,$AAAA,$AAAA,$AAAA,$AAAA,$AAA0
        dc.w      $5555,$5555,$5555,$5555,$5555,$5550
        dc.w      $AAAA,$AAAA,$AAAA,$AAAA,$AAAA,$AAA0
        dc.w      $5555,$5555,$5555,$5FD5,$5555,$5550
```

```
        dc.w    $AAAA,$AAAA,$AAAA,$B06A,$AAAA,$AAA0
        dc.w    $5555,$5555,$55FF,$E03D,$5555,$5550
        dc.w    $AAAA,$AAAA,$AB83,$000A,$AAAA,$AAA0
        dc.w    $D555,$5555,$5701,$FFEF,$5555,$5550
        dc.w    $EAAA,$AAAA,$AC00,$002A,$AAAA,$AAA0
        dc.w    $F555,$5555,$5FF7,$F7A7,$5555,$5550
        dc.w    $FAAA,$AAAA,$B00C,$18AE,$AAAA,$AAA0
        dc.w    $FD55,$5555,$7FF8,$0E9B,$5555,$5550
        dc.w    $E0AA,$AAAA,$C000,$02B2,$AAAA,$AAA0
        dc.w    $6555,$5555,$FFFF,$FC63,$5555,$5550
        dc.w    $B2AA,$AAAB,$0000,$04C6,$AAAA,$AAA0
        dc.w    $3555,$5555,$0700,$058B,$5555,$5550
        dc.w    $9AAA,$AAAB,$0880,$0712,$AAAA,$AAA0
        dc.w    $5955,$5555,$0F80,$0627,$5555,$5550
        dc.w    $A2AA,$AAAB,$0880,$044A,$AAAA,$AAA0
        dc.w    $5555,$5555,$0880,$0493,$5555,$5550
        dc.w    $AAAA,$AAAB,$0000,$0522,$AAAA,$AAA0
        dc.w    $5555,$5555,$03FC,$0647,$5555,$5550
        dc.w    $AAAA,$AAAB,$0204,$048C,$AAAA,$AAA0
        dc.w    $5555,$5555,$0204,$0519,$5555,$5550
        dc.w    $AAAA,$AAAB,$03FC,$0632,$AAAA,$AAA0
        dc.w    $5555,$5555,$0000,$0465,$5555,$5550
        dc.w    $AAAA,$AAAB,$0000,$04CA,$AAAA,$AAA0
        dc.w    $5555,$5555,$060C,$0595,$5555,$5550
        dc.w    $AAAA,$AAAB,$0FF8,$072A,$AAAA,$AAA0
        dc.w    $5555,$5555,$0000,$0655,$5555,$5550
        dc.w    $AAAA,$AAAB,$0000,$04AA,$AAAA,$AAA0
        dc.w    $5555,$5555,$0000,$0555,$5555,$5550
        dc.w    $AAAA,$AAAB,$FFFF,$FEAA,$AAAA,$AAA0
        dc.w    $5540,$0000,$0000,$0000,$0000,$1550
        dc.w    $AAA0,$0000,$0000,$0000,$0000,$0AA0
        dc.w    $5543,$C71E,$49EF,$9CF9,$C722,$1550
        dc.w    $AAA2,$2220,$5202,$2220,$88B2,$0AA0
        dc.w    $5542,$221C,$61C2,$3E20,$88AA,$1550
        dc.w    $AAA2,$2202,$5022,$2220,$88A6,$0AA0
        dc.w    $5543,$C73C,$4BC2,$2221,$C722,$1550
        dc.w    $AAA0,$0000,$0000,$0000,$0000,$0AA0
        dc.w    $5540,$0000,$0000,$0000,$0000,$1550
        dc.w    $AAA0,$0000,$0000,$0000,$0000,$0AA0
        dc.w    $5555,$5555,$5555,$5555,$5555,$5550
        dc.w    $AAAA,$AAAA,$AAAA,$AAAA,$AAAA,$AAA0
        dc.w    $5555,$5555,$5555,$5555,$5555,$5550
        dc.w    $AAAA,$AAAA,$AAAA,$AAAA,$AAAA,$AAA0
        dc.w    $5555,$5555,$5555,$5555,$5555,$5550
        dc.w    $AAAA,$AAAA,$AAAA,$AAAA,$AAAA,$AAA0
        dc.w    $5555,$5555,$5555,$5555,$5555,$5550

end
```

The next example tests out raster use. A raster is basically a graphic area which combines with a source range through a logical AND, and the desired logical operation is copied to the destination range. The comparison of the source range with the raster naturally occurs within the BITBLT function. The source range itself stays independent.

p_mask and p_addr correspond to the variables _patptr and _patmsk through the function $A004, HORIZONTAL LINE. The variable p_nxln gives the offset for the next line of the raster, and must be an even number, so a line from any number of 16 bit words must coincide, as well as source and destination.

A raster can usually be multicolor. The individual bitplanes must then be overlapped word for word as described in the beginning of this chapter. The raster index mask (`p_mask`) gives which raster line should be combined with the source line. From the source line the number of raster line comes from AND and `p_mask`. This is the usual count:

Raster Lines	p_mask
2	1
4	3
8	7
16	15

The blitter has 16 registers of 16 bits into which a raster can be loaded.

This sample program is almost identical to the earlier BITBLT demo. Just replace the material at the `do_blit` and `raster` labels with the coding below. Then save the new version of BITBLT under another name.

```
;*********************************************************************
;                                                                    *
;         bitblt demo changes                                        *
;         copy one-color range to monchrome screen using a raster    *
;                                                                    *
;*********************************************************************

do_blit   lea       para(pc),a6         ;pointer to parameter block

          move      #92,b_width(a6)     ;width in pixels
          move      #52,b_height(a6)    ;height in pixels

          move      #1,planes(a6)       ;monochrome
```

```
        move      #1,fg_col(a6)       ;foreground color
        move      #0,bg_col(a6)       ;background color

        move.l    #$03030303,op_tab(a6) ;replace mode

;                                      transfer source data
        move      #0,s_xmin(a6)       ;source from upper left corner
        move      #0,s_ymin(a6)
        move.l    #source,s_form(a6) ;source address

        move      #2,s_nxwd(a6)       ;2 byte offset to next word
        move      #12,s_nxln(a6)      ;80 byte offset to next line
        move      #2,s_nxpl(a6)       ;2 byte offset - next color plane
;                                      dest is screen

        move      #200,d_xmin(a6)     ;x-coordinate on screen
        move      #100,d_ymin(a6)     ;y-coordinate on screen

        move      #physbase,-(sp)
        trap      #xbios              ;get screen address
        addq.l    #2,sp

        move.l    d0,d_form(a6)       ;use as dest address

        move      #2,d_nxwd(a6)       ;2 byte offset of next word
        move      #80,d_nxln(a6)      ;80 byte offset to next line
        move      #2,d_nxpl(a6)       ;2 byte offset of next color
                                      ;plane

        move.l    #raster,p_addr(a6) ;use raster
        move      #2,p_nxln(a6)       ;offset of next raster line
        move      #0,p_nxpl(a6)       ;single color raster
        move      #1,p_mask(a6)       ;raster index mask

        dc.w      bitblt              ;execute bitblt
        rts

        align

raster  dc.w      %1010101010101010  ;first raster line
        dc.w      %0101010101010101  ;second raster line

para:   ds.b      76        ;76-byte parameter block

;  source and rest of original program follow....
```

Every other pixel is deleted, giving us a raster.

Index

Optional Diskette

For your convenience, the program listings contained in this book are available on an SF354 formatted floppy disk. You should order the diskette if you want to use the programs, but don't want to type them in from the listings in the book.

All programs on the diskette have been fully tested. You can change the programs for your particular needs. The diskette is available for $14.95 plus $2.00 ($5.00 foreign) for postage and handling.

When ordering, please give your name and shipping address. Enclose a check, money order or credit card information. Mail your order to:

Abacus Software
P.O. Box 318
Grand Rapids, MI 49588

Or for fast service, call **616-698-0330**.

Selected Abacus Products for the ATARI® ST™

AssemPro

Machine language development system for the Atari ST

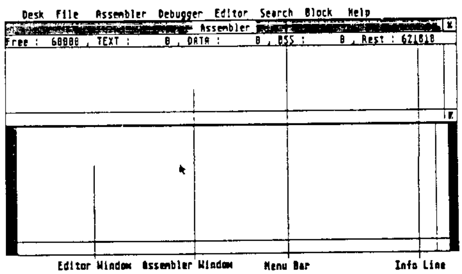
"...I wish I had (AssemPro) a year and a half ago... it could have saved me hours and hours and hours."

—Kurt Madden
ST World

"The whole system is well designed and makes the rapid development of 68000 assembler programs very easy."

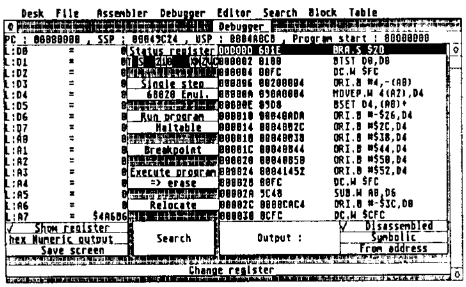
—Jeff Lewis
Input

AssemPro is a complete machine language development package for the Atari ST. It offers the user a single, comprehensive package for writing high speed ST programs in machine language, all at a very reasonable price.

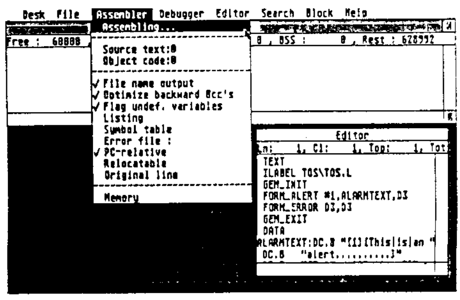


AssemPro is completely GEM-based—this makes it easy to use. The powerful integrated editor is a breeze to use and even has helpful search, replace, block, upper/lower case conversion functions and user definable function keys. **AssemPro**'s extensive help menus summarizes hundreds of pages of reference material.

The fast macro assembler assembles object code to either disk or memory. If it finds an error, it lets you correct it (if possible) and continue. This feature alone can save the programmer countless hours of debugging.



The debugger is a pleasure to work with. It features single-step, breakpoint, disassembly, reassembly and 68020 emulation. It lets users thoroughly and conveniently test their programs immediately after assembly.



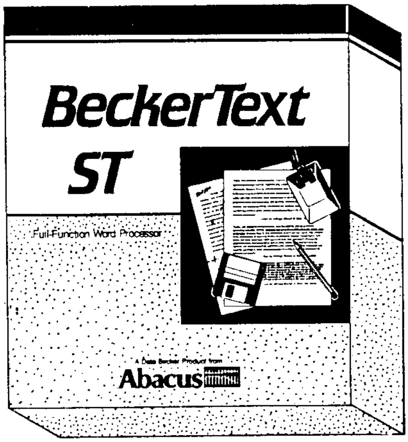
AssemPro Features:

- Full screen editor with dozens of powerful features
- Fast 68000 macro assembler assembles to disk or memory
- Powerful debugger with single-step, breakpoint, 68020 emulator, more
- Helpful tools such as disassembler and reassembler
- Includes comprehensive 175-page manual

AssemPro Suggested retail price: **$59.95**

BeckerText ST

The High-Powered Word Processing Package for the ST



A word processing package for serious Atari ST owners. Because **BeckerText** is more than a word processor.

It has all the features of our **TextPro**, and more: WYSIWYG formatting and printing, graphic merge capabilities, automatic hyphenation and indexing of your documents.

But **BeckerText** also does a few things that you might not expect...like calculate numbers within text, with templates for calculations in up to five columns. (It's just like having a spreadsheet program built into your word processor!). **BeckerText** prints up to five columns of text a page for professional-looking newsletters, presentations, reports, etc. It even has two expandable spelling checkers for 100% spelling accuracy.

BeckerText is also a perfect choice for C language programmers as an extremely flexible C editor. Whether you're deleting, adding or duplicating a block of C source code, **BeckerText** does it all, automatically. The online dictionary can double as a C syntax checker—catch those syntax errors immediately.

BeckerText gives you the power and flexibility to produce the professional-quality documents that you demand. It adapts to most popular dot-matrix and letter-quality printers. Includes a comprehensive tutorial, manual and glossary.

When you need more from your word processor than just word processing, you need **BeckerText**. Discover the power of **BeckerText**.

Suggested retail price: $99.95

BeckerText Features:

- Select options from dropdown menus or shortcut keys
- Fast WYSIWYG formatting
- Bold, italic, underline, superscript and subscript characters
- Automatic wordwrap and page numbering
- Sophisticated tab and indent options, with centering & margin justification
- Move, Copy, Delete, Search & Replace options
- Automatic hyphenation & automatic indexing
- Write up to 999 characters per line with horizontal scrolling feature
- Online dictionary checks spelling as you're writing
- Spelling checker interactively proofs text
- Calculates numbers within text—use templates to calculate in columns
- Customize up to 30 function keys to store often-used text and macro commands
- Merge graphics into documents
- Includes ***BTSnap*** program for converting text blocks to graphics
- C-source mode for quick and easy C language program editing
- Multiple-column printing—up to five columns on a single page
- Adapts to virtually any dot-matrix or letter-quality printer
- Load & save files through the RS-232 port
- Comprehensive tutorial and manual
- Not copy protected

Selected Abacus Products for the ATARI® ST™

Chartpak ST

Professional-quality charts and graphs on the Atari ST

In the past few years, Roy Wainwright has earned a deserved reputation as a topnotch software author. **Chartpak ST** may well be his best work yet. **Chartpak ST** combines the features of his **Chartpak** programs for Commodore computers with the efficiency and power of GEM on the Atari ST.

Chartpak ST is a versatile package for the ST that lets the user make professional quality charts and graphs fast. Since it takes advantage of the ST's GEM functions, **Chartpak ST** combines speed and ease of use that was unimaginable til now.

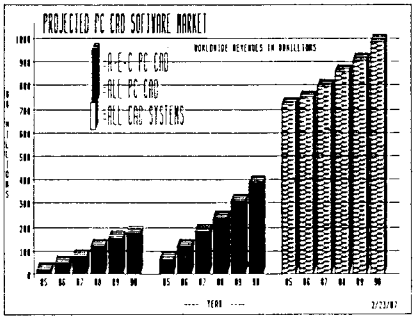
The user first inputs, saves and recalls his data using **Chartpak ST**'s menus, then defines the data positioning, scaling and labels. **Chartpak ST** also has routines for standard deviation, least squares and averaging if they are needed. Then, with a single command, your chart is drawn instantly in any of 8 different formats—and the user can change the format or resize it immediately to draw a different type of chart.

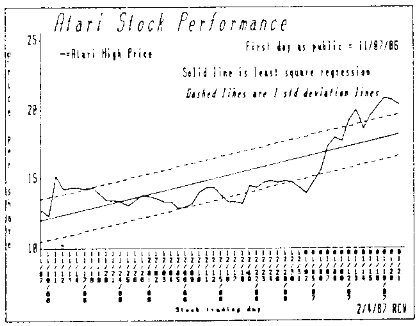
In addition to direct data input, **Chartpak ST** interfaces with ST spreadsheet programs spreadsheet programs (such as **PowerLedger ST**). Artwork can be imported from **PaintPro ST** or DEGAS. Hardcopy of the finshed graphic can be sent most dot-matrix printers. The results on both screen and paper are documents of truly professional quality.

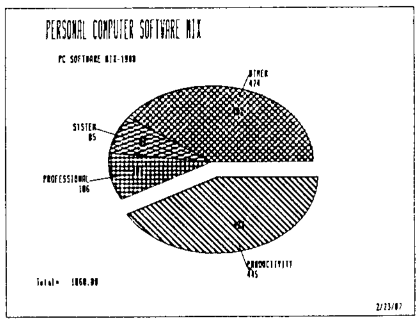
Your customers will be amazed by the versatile, powerful graphing and charting capabilities of **Chartpak ST** .

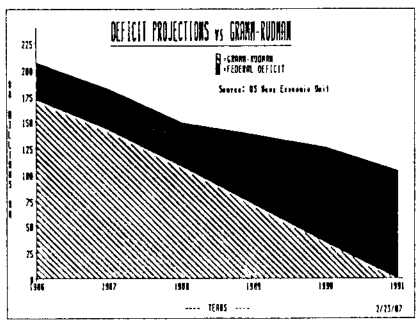
Chartpak ST works with Atari ST systems with one or more single- or double-sided disk drives. Works with either monochrome or color ST monitors. Works with most popular dot-matrix printers (optional).

Chartpak ST Suggested Retail Price: **$49.95**









Selected Abacus Products for the ATARI ST™

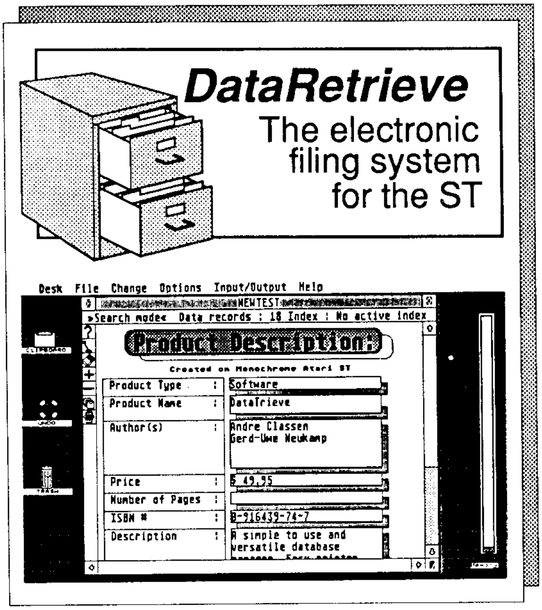
DataRetrieve

(formerly FilePro ST)

Database management package for the Atari ST

"DataRetrieve is the most versatile, and yet simple, data base manager available for the Atari 520ST/1040ST on the market to date."

—Bruce Mittleman
Atari Journal



DataRetrieve is one of Abacus' best-selling software packages for the Atari ST computers—it's received highest ratings from many leading computer magazines. **DataRetrieve** is perfect for your customers who need a powerful, yet easy to use database system at a moderate price of $49.95.

DataRetrieve's drop-down menus let the user quickly and easily define a file and enter information through screen templates. But even though it's easy to use, **DataRetrieve** is also powerful. **DataRetrieve** has fast search and sorting capabilities, a capacity of up to 64,000 records, and allows numeric values with up to 15 significant digits. **DataRetrieve** lets the user access data from up to four files simultaneously, indexes up to 20 different fields per file, supports multiple files, and has an integral editor for complete reporting capabilities.

DataRetrieve's screen templates are paintable for enhanced appearance on the screen and when printed, and data items may be displayed in multiple type styles and font sizes.

The package includes six predefined databases for mailing list, record/video albums, stamp and coin collection, recipes, home inventory and auto maintenance that users can customize to their own requirements. The templates may be printed on Rolodex cards, as well as 3 x 5 and 4 x 5 index cards. **DataRetrieve**'s built-in RAM disks support lightning-fast operation on the 1040ST. **DataRetrieve** interfaces to **TextPro** files, features easy printer control, many help screens, and a complete manual.

DataRetrieve works with Atari ST systems with one or more single- or double-sided disk drives. Works with either monochrome or color monitors. Printer optional.

DataRetrieve Features:

- Easily define your files using drop-down menus
- Design screen mask size to 5000 by 5000 pixels
- Choose from six font sizes and six text styles
- Add circles, boxes and lines to screen masks
- Fast search and sort capabilities
- Handles records up to 64,000 characters in length
- Organize files with up to 20 indexes
- Access up to four files simultaneously
- Cut, past and copy data to other files
- Change file definitions and format
- Create subsets of files
- Interfaces with **TextPro** files
- Complete built-in reporting capabilities
- Change setup to support virtually any printer
- Add header, footer and page number to reports
- Define printer masks for all reporting needs
- Send output to screen, printer, disk or modem
- Includes and supports RAM disk for high-speed 1040ST operation
- Capacities: max. 2 billion characters per file
  max. 64,000 records per file
  max. 64,000 characters per record
  max. fields: limited only by record size
  max. 32,000 text characters per field
  max. 20 index fields per file
- Index precision: 3 to 20 characters
- Numeric precision: to 15 digits
- Numeric range $\pm 10^{-308}$ ti $\pm 10^{308}$

DataRetrieve Suggested Retail Price: **$49.95**

Selected Abacus Products for the ATARI® ST™

PaintPro

Design and graphics software for the ST

PaintPro is a very friendly and very powerful package for drawing and design on the Atari ST computers that has many features other ST graphic programs don't have. Based on GEM™, **PaintPro** supports up to three active windows in all three resolutions—up to 640x400 or 640x800 (full page) on monochrome monitor, and 320 x 200 or 320 x 400 on a color monitor.

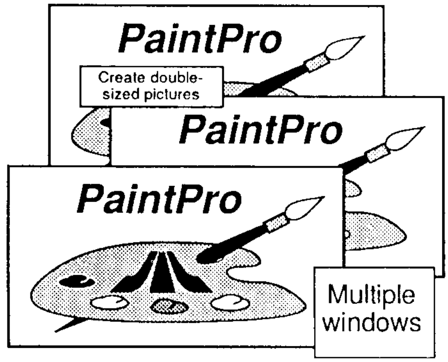
PaintPro's complete toolkit of functions includes text, fonts, brushes, spraypaint, pattern fills, boxes, circles and ellipses, copy, paste and zoom and others. Text can be typed in one of four directions—even upside down—and in one of six GEM fonts and eight sizes. **PaintPro** can even load pictures from "foreign" formats (ST LOGO, DEGAS, Neochrome and Doodle) for enhancement using **PaintPro**'s double-sized picture format. Hardcopy can be sent to most popular dot-matrix printers.

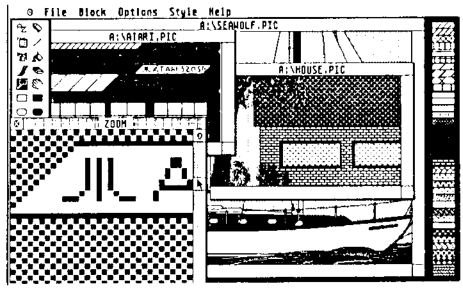
PaintPro Features :

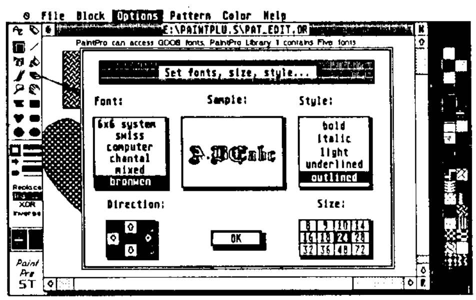
- Works in all 3 resolutions (mono, low and medium)
- Four character modes (replace, transparent, inverse XOR)
- Four line thicknesses and user-definable line pattern
- Uses all standard ST fill patterns and user definable fill patterns
- Max. three windows (dependng on available memory)
- Resolution to 640 x400 or 640x800 pixels (mono version only)
- Up to six GDOS type fonts, in 8-, 9-, 10-, 14-, 16-, 18-, 24- and 36-point sizes
- Text can be printed in four directions
- Handles other GDOS compatible fonts, such as those in **PaintPro Library # 1**
- Blocks can be cut and pasted; mirrored horizontally and vertically; marked, saved in LOGO format, and recalled in LOGO
- Accepts **ST LOGO, DEGAS, Doodle & Neochrome** graphics
- Features help menus, full-screen display, and UNDO using the right mouse button
- Most dot-matrix printers can be easily adapted

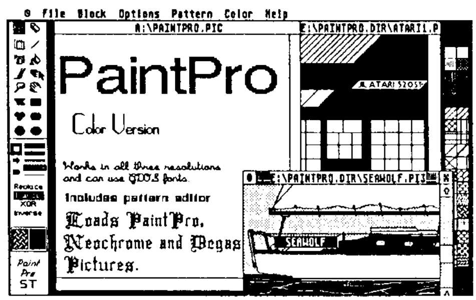
PaintPro works with Atari ST systems with one or more single- or double-sided disk drives. Works with either monochrome or color ST monitors. Printer optional.

PaintPro Suggested Retail Price: **$49.95**









Atari ST, 520ST, 1040ST, TOS, ST BASIC and ST LOGO are trademarks or registered trademarks of Atari Corp.

GEM is a registered trademark of Digital Research Inc.

Selected Abacus Products for the ATARI® ST™

PCBoard Designer

Interactive CAD Package for printed circuit board layout on the Atari ST

PCBoard Designer is an interactive, computer-aided design package for creating electronic printed circuit boards. It drastically reduces the cost, time and tedium of making one or two-sided pc boards. The advanced features of **PCBoard Designer** can improve a designer's productivity ten-fold.

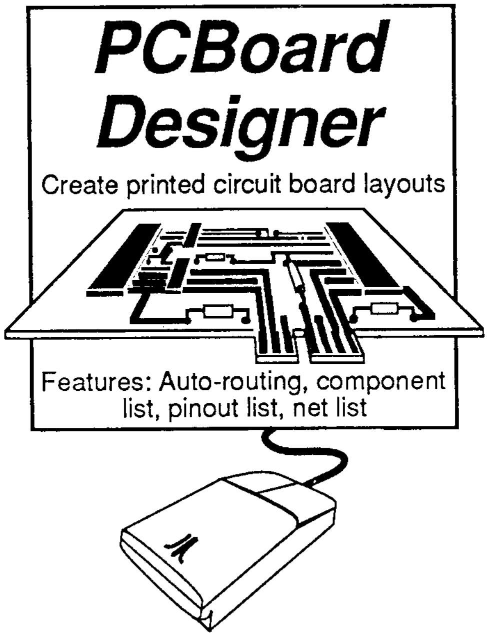
PCBoard Designer is easy to use. Design parameters are conveniently entered and modified at the computer. The user can position the components interactively by moving them on the screen using the mouse. This lets the user compare alternative component placement with no extra effort.

As the user position the components on the screen using the mouse, **PCBoard Designer** displays the new connections! Automatic routing is fast and precise.

The most powerful feature of **PCBoard Designer** is its fast <u>automatic routing</u> capability. Traces are automatically and precisely drawn on the screen. If the user changes the design, the traces can be immediately redrawn—this feature alone can save an enormous amount of time and money. In addition, the user has options of <u>45° or 90° angle traces</u>, different trace widths, routing from pin to pin, pin to BUS, BUS to BUS, as well as two-sided boards. The <u>rubberbanding</u> feature lets you see the user-defined components during placement—and the user can reposition your components at any time during the design process.

PCBoard Designer prints the completed layout to any Epson/compatible dot matrix printer and Hewlett-Packard plotters at 2:1. The high-quality printout is camera-ready for final photo-etching. **PCBoard Designer** also prints the component layout, and lists every component and connection as well.

In conjuction with the Atari ST computer, **PCBoard Designer** is the most affordable PC board CAD package available. It boasts features that not available on systems costing thousands of dollars.

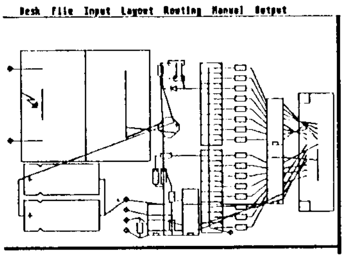


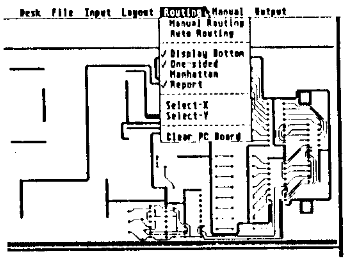
How PCBoard Designer works

There are basically four steps in creating a working pc board:

- **Specify the components:** For example, IC4 is an integrated circuit that fits in a 14-pin dual-in-line socket. You can also define custom component types, for example a 99-pin circular IC.
- **Specify the connections:** For example, pin 2 of integrated circuit IC4 is connected to lead 1 of transistor Q7. You can change the connections at any time.
- **Position the components:** Move the components to their desired position on the screen by using the Atari ST's mouse. You can reposition them at any time. **PCBoard Designer** automatically routes the connections when you're done.
- **Output the design:** The finished board can be printed on any Epson/compatible printer or Hewlett-Packard plotter. The printout is suitable for photoetching. You can also print the component layout (for silkscreening), the component list, and the list of connections.

Selected Abacus Products for the ATARI® ST™





"I was thoroughly impressed... a powerful, multi-featured design tool that can be easily learned and used."

—Bill Marquardt
Input magazine

"What makes this program especially easy to use is that the components are drawn to scale on the screen. This comes in handy when it's time for the user to position the components.

*"The author invested a lot of blood, sweat and tears writing this portion of the program. **PCBoard Designer** has a wide selection of options here that allow for flexible design. Either all of the connections or an individual connection can be routed at the click of the mouse button.*

"One thing is clear, though: author Florian Sachse has produced a first-class software package. This program will undoubtedly be a godsend to the engineer and electronic hobbyist alike.

—**DATA WELT** Magazine
APRIL 1986

Abacus Software, Inc.
5370 52nd St. S.E.
Grand Rapids, MI 49508

(616) 698-0330

PCBoard Designer (continued)

PCBoard Designer Features:

- PC boards may be one-sided or two-sided
- Components are drawn to scale on the screen
- Custom components may be used
- Component positioning is flexible and interactive
- Components may be roatated in 90º increments
- Traces are drawn using sophisticated and fast automatic routing techniques—the user has the ability to make 45º and 90º angle traces, variable trace widths, pin to pin, pin to bus and bus to bus routing
- "Blockades" may be inserted onto the board to handle special cases
- Printout is high quality and suitable for photo-reproduction
- Features are clearly displayed and are selectable from the drop-down menus

Hardware Requirements:

Computer: Atari 520ST or 1040ST computer and monochrome monitor with one or more single-sided, double-sided, or hard disk drives.

Printers/Plotters: PCBoard Designer prints your completed layout to any Epson or Epson-compatible dot matrix printer at 2:1. Epson FX-80, FX-100, Toshiba, NEC P6 and P7 or compatible printersrequired for photo-ready traces. Also works on Hewlett/Packard plotters.

Package: Includes 100 page manual in 3-ring slipcase binder and program diskette.

Free phone support to registered users.

PCBoard Designer can dramatically improve design productivity by eliminating many redundant steps and time-consuming alterations. With all of its advanced time-saving capabilities, **PCBoard Designer** pays for itself after the first successfully designed board.

PCBoard Designer

Suggested Retail Price:

$195.00

Selected Abacus Products for the ATARI® ST™

PowerLedger ST

(formerly PowerPlan ST)

Spreadsheet/Graphics package for the Atari ST

"A superior spreadsheet program for weekend bookeeping to the heavyweight job costing applications, (Powerledger ST) is a definite winner."

—Judi Lambert
ST World

Ever since VisiCalc and Lotus 1-2-3 stormed the personal computer market, the computer has become an important planning tool. **PowerLedger ST** brings the power of electronic spreadsheets to the Atari ST line of computers—it lets the user quickly perform hundreds of calculations and "what-if" analyses for business applications, and crunch raw data into meaningful, comprehensible information, to keep track of budgets, expenses and statistics.

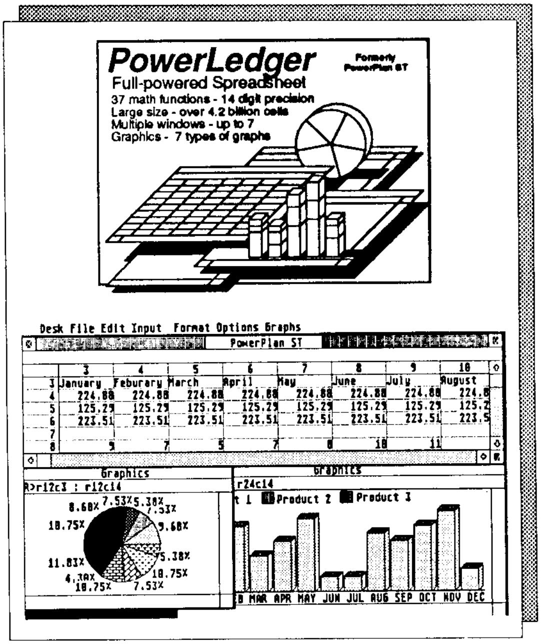
PowerLedger ST is a powerful analysis package that features a large spreadsheet (65,536 X 65,536 cells—over 4 billion data items). It also contains a built-in calculator, online notepad, and integrated graphics.

PowerLedger ST is also very easy to learn, since it uses the familiar GEM features built into the ST. And PowerLedger ST can use multiple windows—up to seven. Data from the spreadsheet can be graphically summarized in in pie charts, bar graphs and line charts, and displayed simultaneously with the spreadsheet. For example, one window can display part of the spreadsheet; a second window a different part; and a third window, a pie or bar chart of the data.

PowerLedger ST works hand-in-hand with our **DataTrieve** data management package and our **TextPro** wordprocessing package.

PowerLedger ST's extraordinary combination of data and graphic power, ease of use and low price makes it a perfect tool for every ST owner's financial planning needs.

PowerLedger ST works with Atari ST systems with one or more single- or double-sided disk drives. Works with either monochrome or color ST monitors. Works with most popular dot-matrix printers (optional).



PowerLedger ST Features:

- Familiar drop-down menus make PowerPlan easy to learn and use
- Large capacity spreadsheet serves all the user's analysis needs
- Convenient built-in notepad documents your important memos
- Flexible online calculator gives you access to quick computations
- Powerful options such as cut, copy and paste operations speeds the user'swork
- Integrated graphics summarize hundreds of data items
- Draws pie, bar, 3D bar, line and area charts automatically (7 chart types)
- Multiple windows emphasize the user's analyses
- Accepts information from DataTrieve, our database management software
- Passes data to **TextPro** wordprocessing package
- Capacities: maximum of 65,535 rows
  maximum of 65,535 columns
  variable column width
  numeric precision of 14 digits
  maximum value 1.797693 x 10^{308}
  minimum value 2.2 x 10^{-308}
  37 built-in functions

PowerLedger ST Suggested Retail Price: **$79.95**

Selected Abacus Products for the ATARI® ST™

TextPro

Wordprocessing package for the Atari ST

"TextPro seems to be well thought out, easy, flexible anf fast. The program makes excellent use of the GEM interface and provides lots of small enhancements to make your work go more easily... if you have an ST and haven't moved up to a GEM word processor, pick up this one and become a text pro."

—John Kintz
ANTIC

"TextPro is the best wordprocessor available for the ST"

—Randy McSorley
Pacus Report

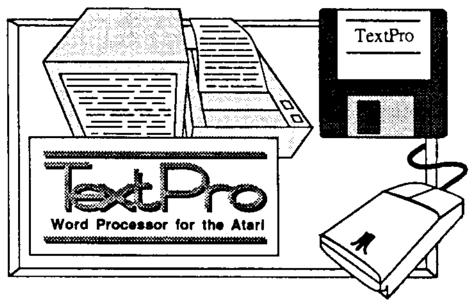
TextPro is a first-class word processor for the Atari ST that boasts dozens of features for the writer. It was designed by three writers to incorporate features that they wanted in a wordprocessor—the result is a superior package that suits the needs of all ST owners.

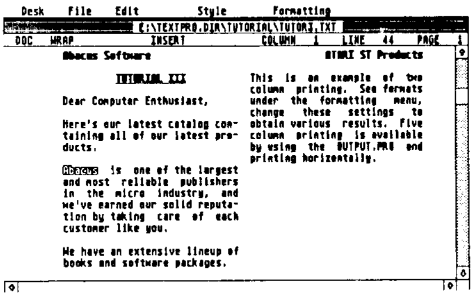
TextPro combines its "extra" features with easy operation, flexibility, and speed—but at a very reasonable price. The two-fingered typist will find **TextPro** to be a friendly, user-oriented program, with all the capabilities needed for fine writing and good-looking printouts. **Textpro** offers full-screen editing with mouse or keyboard shortcuts, as well as high-speed input, scrolling and editing. **TextPro** includes a number of easy to use formatting commands, fast and practical cursor positioning and multiple text styles.

Two of **TextPro**'s advanced features are automatic table of contents generation and index generation —capabilities usually found only on wordprocessing packages costing hundreds of dollars. **TextPro** can also print text horizontally (normal typewriter mode) or vertically (sideways). For that professional newsletter look, **TextPro** can print the text in columns—up to six columns per page in sideways mode.

The user can write form letters using the convenient Mail Merge option. **TextPro** also supports GEM-oriented fonts and type styles—text can be **bold**, underlined, *italic*, superscript, outlined, etc., and in a number of point sizes. **TextPro** even has advanced features for the programmer for development with its Non-document and C-sourcecode modes.

TextPro Suggested Retail Price: **$49.95**





TextPro ST Features:

- Full screen editing with either mouse or keyboard
- Automatic index generation
- Automatic table of contents generation
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